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a quarterly journal on animal health, production and products

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WORLD
animal
REVIEW *a quarterly journal on animal health, production and products* *no. 29 - 1979*

WORLD ANIMAL REVIEW is a quarterly journal reviewing developments in animal production, animal health and animal products, with particular reference to these spheres in Asia, Africa and Latin America. It is published by the Food and Agriculture Organization of the United Nations. FAO was founded in Quebec, Canada, in October 1945, when the Member Nations agreed to work together to secure a lasting peace through freedom from want. The membership of FAO numbers 144 nations.

Director-General: Edouard Saouma

WORLD ANIMAL REVIEW [abbreviation: **Wld Anim. Rev.** (FAO)] is prepared by FAO's Animal Production and Health Division, which is one of five divisions in the Agriculture Department. The Division is subdivided into three technical services concerned with animal production, meat and milk development, and animal health.

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COVER: Swine feeding in Japan.

International trade in meat

veterinary aspects and the role of FAO

H.O. Königshöfer

The total value of all meat in the international meat trade is estimated to be of the order of $12 thousand million per year. Obviously, a trade of such magnitude requires a reasonable degree of economic security, including reliability of supply and security of market access. The possibility of a commodity agreement, or other such measure, for meat has been proposed. However, the negotiations in progress are faced with a number of problems.

It is doubtful if the veterinary questions are the deciding obstacle. There are other controversial issues of a purely economic or political nature such as the international feed-grain trade versus the meat trade. But the veterinary problems — mainly the animal health ones — are those that cause the greatest legal, technical and procedural difficulties. These difficulties begin even when deciding on an appropriate forum to discuss the subject: economists, for good reasons, are usually reluctant to discuss technical implications and, likewise, veterinarians refuse to discuss matters of trade policy. These attitudes, regrettable as their consequences may be, are not quite unjustified. Recommendations made by veterinary groups with the intention of facilitating international trade may sometimes have no relation whatsoever to actual trade problems; similarly, decisions taken by trade policy groups may prove impractical on veterinary grounds or may even be entirely meaningless when it comes to implementation at the technical level.

These basic difficulties may help to explain some of the reasons for the lack of progress in multilateral international meat trade agreements. In principle, the objectives of any international veterinary agreement are clear: the agreement should help to prevent the spread of contagious animal diseases; it should protect humans against health hazards from animal sources; and, at the same time, it should facilitate the promotion of international trade. The problem is intimately connected with the health clause in international trade agreements.

Under the General Agreement on Tariffs and Trade (GATT), GATT Member Governments have reserved their right to adopt and enforce measures necessary to protect human, animal or plant life or health, "*subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade.*" Article XX, item b). Almost literally the same provision has been included in several other multilateral conventions, such as the Convention of Montevideo and the Cartagena Agreement. The principle of non-discrimination expressed in these health clauses is the only binding commitment that exists at present with regard to the application of veterinary measures to the international meat trade. There are, however, many bilateral veterinary agreements, and there is also the multilateral International Agreement for the Creation of the International Office of Epizootics, signed in Paris on 25 January 1924, by which member states undertake to cooperate in the control of epizootic diseases. This agreement contains a number of precise commitments, such as international notification of certain animal disease outbreaks. It is, however, not directly related to international trade commitments, because at that time there was no question of any economic arrangement aimed at the liberalization of the international meat trade.

Another international veterinary convention, drafted under the auspices of the League of Nations, was signed by 22 states in Geneva on 20 February 1935 and came into force in 1938, after ratification by 5 signatory governments (League of Nations Treaty series N. 4310, N. 4486 and N. 4487). This convention, although technically obsolete to a large extent, is still of interest because it shows that multilateral veterinary agreements are possible.

As to the present situation, it was certainly a great step forward that the principle of non-discrimination expressed in GATT Article XX, and in the health clauses of other multilateral trade conventions, has been formally agreed upon by a large number of countries. Nevertheless, considering that veterinary measures applied to intranational trade are governed by laws and regulations covering hundreds of pages, in some countries even thousands of pages, it may be considered as an extremely modest beginning that the commitment concerning the application of veterinary measures to international trade is governed only by this short provision in the health clause.

In this connection, two main questions arise:

- Is it possible to apply the principle of non-discrimination in practice? As a purely moral intention, of course it is possible; but in a legal sense, is it possible to apply this principle in such a way that not only is justice done, but also that it *becomes evident*, in objective terms, that justice has been done? And if so, are more detailed international arrangements for this purpose necessary and feasible, or is

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- the present health clause sufficient?
- Is the implementation of the principle of non-discrimination the only veterinary precondition required for an international meat trade agreement?

Whatever the answers to these questions may be, it is obvious that commercial agreements are bound to remain of very limited value if insufficiently defined sanitary clauses can at any time, and even in good faith, be invoked for unpredictable interference with international trade and the virtual suspension of the trade agreement concerned.

Basic technical aspects. Veterinary measures applicable to the international meat trade have two main objectives: the protection of human health and the protection of animal health. The more complex problems are those related to the protection of animal health.

The viruses of foot-and-mouth disease, rinderpest, swine fever and African swine fever, and the causal agents of several other animal diseases may be contained in the meat obtained from infected animals. The infection does not always produce symptoms in the individual animal that could be noticed at ante-mortem and post-mortem inspection in the slaughterhouse. It is therefore of paramount importance for animal-disease control to prevent the shipment of any meat from infected areas into non-infected areas. Regulatory veterinary measures for that purpose are being applied to international trade within the boundaries of nearly every country and nobody questions the legitimacy of similar restrictive measures being applied to meat tendered for importation from abroad. Up to that point, there is nothing controversial.

A point that has been much discussed, however, is the size of the area considered as potentially infected, and also the duration of the restrictions applied to such areas. At the national level, inside the meat-importing countries, the restricted area is seldom larger than a few villages. If the same or a similar infection occurs in a meat-exporting country, the veterinary authorities of importing countries usually tend to regard the entire country as infected. Some of these countries are larger than the whole of Western

A processor checking bagged sides of beef in the freezer of a Buenos Aires meat-processing plant.

Europe. It cannot be denied that this is an obvious disparity, which *prima facie* may appear to be an unjustifiable discrimination. But the matter is far from being as simple as that and, at least under present circumstances, valid technical reasons can be given for this disparity.

The core of the problem is that the absence of infection in those areas of the exporting country where no outbreaks have been recorded must be demonstrated with the same degree of reliability as in the non-infected areas of the importing country. This depends on the efficiency of disease surveillance, the efficiency of measures through which the infected area is isolated from the rest of the country, and also the speed and efficiency of the sanitary action in the outbreak area, because the risk of further spread increases with the duration of the outbreak. Good sanitary practice at the national level is thus the first technical precondition for a more satisfactory delimitation of those areas, which, for national and international trade purposes, must be regarded as infected. For international trade purposes it is equally important that all sanitary measures, including surveillance and quarantine, be implemented in such a manner that the veterinary authorities of importing countries are convinced of their efficiency and that routine procedures for monitoring are agreed upon. The establishment of officially certified specific disease-free areas, in the framework of national eradication programmes, appears to be the most appropriate and promising approach for these purposes.

It has been suggested that uniform regulations for the control of animal diseases should be agreed upon internationally and adopted under national legislation by all countries. To be technically feasible, this concept requires some essential modifications. It is possible to agree on certain basic principles, and there is in fact worldwide consensus based on the common concepts of veterinary science. The way in which these principles are most efficiently put into practice, however, depends on prevailing conditions of livestock production, the disease situation, patterns of trade movement, feasibility of control measures and many other factors that vary from country to country and, in the larger countries, even from one region to another. Different regulatory approaches would therefore be required to apply the same basic principles with an equivalent degree of efficiency. The type of regulations that in Europe has led to the eradication of many contagious animal diseases would be totally inefficient under conditions of extensive livestock production. If national laws and regulations are taken into consideration for international trade purposes, their adequacy under local conditions, the efficiency of their implementation, and their conformity with the generally recognized valid principles should in most instances be more important criteria than their formal similarity to the regulations of the importing country. The deciding factor is the equivalence of effects.

The degree of risk involved in meat imports depends not only on conditions prevailing in the exporting country, but also on many factors that determine the degree of vulnerability of the importing country. A country where no pigs are raised obviously need not fear the introduction of pig diseases. Also the cost and difficulty of eradication, if a disease should be introduced from abroad, vary considerably from country to country. It is therefore justified for countries with extensive livestock production of the ranching type to take more stringent precautions against the introduction of foot-and-mouth disease than countries where most of the production is based on small, intensively or semi-intensively operated farms. In the latter case, good surveillance is possible and an outbreak should normally be detected immediately and eradicated by slaughter and compensation of one or two small herds.

The veterinary measures for the protection of human health are based mainly on ante-mortem and post-mortem inspection at slaughter, and on the enforcement of rules for the hygienic handling of meat in slaughterhouses, cutting plants, cold stores and similar establishments. Most of the relevant activities are implemented in closed institutions, where conditions are not (or at least should not be) as dissimilar as the field conditions in different countries. The problems related to the application of veterinary measures to the international meat trade for the protection of human health are therefore less complex than those related to animal health. In fact national meat hygiene legislation at present in force shows great similarities in most of the major meat-exporting and meat-importing countries. There are, however, administrative problems related to the official approval of export slaughterhouses, and some feel that in certain instances the practices used at present leave room for improvement. Furthermore, the problem of chemical residues from drugs and pesticides is gaining in importance. In many instances, the use of these products is unavoidable for adequate animal health care and for good agricultural practice under tropical and subtropical conditions. This should be taken into consideration insofar as it is compatible with the purpose of protecting the health of consumers.

The proper use of drugs and pesticides, particularly as regards the observance of legally required delays between the last drug application and slaughter, requires close official veterinary surveillance in the field, and liaison with the veterinary meat inspection services in the slaughterhouses on a routine basis and directly at the executive level. The same applies to the official surveillance of the origin of slaughter animals from certified disease-free areas (or at least from areas not known to be infected) and their transport to the export slaughterhouse by approved routes and means of transportation.

Action taken by FAO. In the late 1950s, the Organisation for Economic Co-operation and Development (OECD) undertook several studies on the technical requirements that might have a bearing on future measures for the liberalization of the meat trade among its member countries including: meat grading systems, wholesale cuts, and sanitary regulations for livestock and meat. These studies were followed by proposals for common regulations ap-

plicable to the international meat trade, and by the formation of working groups to discuss the proposals. FAO took an active part in this work and continued its activities within the framework of the FAO/WHO [1] *Codex Alimentarius*, while OECD gradually discontinued these activities in the late 1960s.

Some *Codex Alimentarius* documents have resulted from this activity, the most important ones being the *Code of hygienic practices for fresh meat* and the *Code of ante-mortem and post-mortem inspection of slaughter animals*. A code concerning the decisions to be taken at ante-mortem and post-mortem inspection is still under discussion and may also come under the umbrella of the *Codex Alimentarius*.

In 1964, an FAO/WHO/OIE [2] international meeting on basic principles for the control of international traffic of animals and animal products was held in Berne, Switzerland. The conclusions reached provided guidance for FAO activities in subsequent years. This meeting was followed in 1966 by a symposium in Beirut, dealing with the specific regional problems related to trade in the Near East.

The effects of non-tariff trade barriers on the international meat trade, and mainly those trade impediments that are connected with health conditions and health requirements, received particular consideration at the 15th Session of the FAO Conference in November 1969. The Conference, upon the initiative of several South American and African governments, requested, among other related measures, the establishment of an international code for the control of animal diseases and of health regulations for processing. The Conference also asked FAO to study the health regulations that appear to be impeding meat imports and requested that potential exporters be kept informed of these. An interdivisional working group was therefore established in FAO and this produced a study on non-tariff barriers to the international meat trade arising from health requirements. This was published in 1973, as a supplement to the FAO/WHO/OIE *Animal health yearbook*. In October 1973 an FAO expert consultation was held on the same subject in Pendik, Turkey.

The meeting in Pendik also considered the subject of specific disease-free zones as a strategy for disease eradication and as a means of facilitating international trade. This was done in continuation of previous FAO meetings on the same subject, held in Paris (jointly with OIE) and in Khartoum (jointly with OIE and OAU [3]). In spring 1973, there was a thorough discussion of the concept of disease-free zones at a meeting of the FAO Regional Animal Production and Health Commission for the Near East, in Beirut. There were also numerous FAO field activities relating to the establishment of disease-free zones in Kenya, Ethiopia, Sudan, Philippines, Thailand and Indonesia.

The Expert Consultation in Pendik recommended that FAO, with the assistance of a small group of experts, should produce a *Manual on standards of veterinary services, meat hygiene and meat inspection, post-mortem judgement of slaughter animals and establishment of specific disease-free zones*. This was done, and the Manual was published in 1974. The "standard of veterinary services" contained in the Manual was based on the provisions of the international veterinary convention held under the auspices of the League of Nations in 1935 and on the principles agreed upon at the 1964 Berne meeting. It also took account of the view expressed by the Chief Veterinary Officers at OIE meetings and at the OECD working group meetings held in the 1960s. A thorough study of national veterinary legislation in the various countries provided background material. In 1976, this standard was adopted as a guideline by the FAO Regional Animal Production and Health Commission for Asia, the Far East and the South-West Pacific (APHCA).

In addition to these global activities, FAO was also involved in action at the regional and subregional levels. Particularly successful was the action of the Andean Group in South America, which facilitates intra-subregional trade. The system is based on a catalogue of exotic diseases, against which common protective measures are taken, a register of norms that the countries commit themselves to use, except in justified cases of emergency, as the *only* sanitary norms applicable to intra-subregional trade with reason-

Meat-processing plant workers grading beef sides in Buenos Aires.

[1] WHO = World Health Organization.
[2] OIE = Office international des épizooties (International Office of Epizootics).
[3] OAU = Organization of African Unity.

able delays for the registration of new norms, and an index of all sanitary norms applied to the national territory of member countries. This index, presented in a systematic order, facilitates the harmonization of national norms and permits their gradual substitution by common norms. The system is supplemented by a comprehensive, subregional, sanitary-information scheme.

It is generally agreed that reliable veterinary reporting is a precondition for any action taken with a view to reducing the trade-impeding effect of veterinary measures. Only reliable international veterinary reporting permits the substitution of absolute import prohibitions by technically sound conditional requirements, without detriment to sanitary security. The FAO/WHO/OIE Animal Health Yearbook, which has been published since 1958, was established with this purpose in mind. It facilitates the cooperation of veterinary services on measures applied to international trade. It can fulfil its purpose only in combination with the traditional OIE reporting system, operating since the foundation of OIE in 1924.

The FAO Inter-governmental Group on Meat and several other international trade policy groups have discussed the above activities of FAO, particularly those concerned with disease-free zones and the codes and standards published in the Manual. The general opinion appears to be that the establishment of disease-free zones in accordance with internationally agreed principles, and their recognition and monitoring by importing countries, may be an adequate approach to promote and stabilize the international meat trade and at the same time satisfy the legitimate requirements for sanitary safety. The codes and standards, in spite of their non-committal and purely recommendatory character, are likely to produce a stabilizing effect and help to prevent arbitrary discrimination. At a recent African Meat Seminar, held by UNCTAD[4] in Nairobi, Kenya, in March 1978, the question was raised as

A modern slaughterhouse on the outskirts of Skopje, Jugoslavia. Sheep carcasses in the freezing room ready for export.

to whether it would be desirable to establish a group of experts to discuss and possibly revise once more the various codes and standards adopted so far, and published in the Manual. It was concluded that no technical improvement or modification of these documents would change their statutory character of being purely recommendatory. A binding multilateral meat trade agreement would need to be complemented by a binding agreement defining the veterinary measures applicable to that trade more precisely than already accepted under the health clause of GATT Article XX (b). A group of experts would be required to elaborate proposals for such an agreement. So far, however, FAO has received no mandate from its Member Governments to take such action.

Present problems and future outlook. Future developments will depend on the progress of trade negotiations. Arrangements concerning the application of veterinary measures to the international trade can only be supplementary to the arrangements concerning the trade itself. This makes it impossible, at the present stage, to predict the formal framework of future veterinary cooperation related to the international meat trade.

As to the substance of such cooperation, it is certain that adequate veterinary services in both the exporting and importing countries are and will be a precondition for any meaningful arrangement. It is also important that direct contacts between the veterinary services of exporting and importing countries should be authorized by the respective governments on a routine basis, with immediate and direct communication on all technically relevant matters. For bilateral arrangements, it has been recommended that potential exporting countries should have early discussions with potential importing countries to ensure that the standard of veterinary services is acceptable. It appears logical to assume that similar approaches will be desirable also for multilateral or plurilateral arrangements. In this case, the first step might be to agree on certain principles of veterinary cooperation.

It has been suggested that the international organizations should elaborate a "code of behaviour" for the application of veterinary measures to the international meat trade. Such codes of behaviour are common in trade matters but it is questionable whether they would also be feasible for the cooperation of technical services. The "behaviour" of the official veterinary services is governed by laws and regulations. Thus, whatever the contents of an international code of behaviour for the veterinary authorities might be, its implementation would certainly require change in existing legislation.

Most of the present veterinary legislation in the major meat-importing countries dates back to a time when economic protectionism was not regarded as objectionable. The legislator at the beginning of the century had no reason to foresee that import prohibitions based on health grounds might one day be suspected of becoming "disguised restrictions on international trade." This situation has certain consequences that affect the modalities of

[4] UNCTAD = United Nations Conference on Trade and Development.

international veterinary cooperation in a way that differs essentially from principles usually accepted at the national level.

It should be normal practice that veterinarians of an importing country on an official visit to an exporting country, or a potential exporting country, discuss their findings with the veterinary authorities of that country on the spot, and that an official protocol be made, specifying whatever they found objectionable. If the inspections and monitoring authorized by the potential exporting country are found insufficient to permit conclusions, this should also be placed on record. If bacteriological or virological examinations of imported meat are made, the veterinary authorities of the exporting country should be informed and should be allowed to be represented, at least when the samples are taken. For multilateral arrangements an agreement on the basic principles of cooperation would be an indispensable precondition.

Although, at present, international relations between veterinary services are usually handled on a bilateral basis, there are almost always multilateral implications involved. A country wishing to permit imports has to consider not only the sanitary risk for its own livestock, but also possible repercussions of this on the acceptability of its own exports of agricultural produce. In consequence, direct negotiation with a potential exporting country is usually accompanied by consultation with a number of other countries — neighbours and trading partners — whose reactions must be taken into account. The potential exporting country is not, and under present legislation cannot be, fully informed on these consultations, and often does not even know which countries are being consulted. It can hardly be denied that this situation is bound to have an adverse effect on the economic security and stability of the international meat trade.

The unpredictable and relatively frequent changes of technical import-requirements have been criticized by exporters. The criticism has also been voiced that these changes are made without previous warning and without guarantee that the new requirements will remain in force long enough to justify the investments that may be needed. A recent example is the increasing number of European countries that require that beef from South America should be deboned. This is based on animal health considerations, in order to prevent the introduction of foot-and-mouth disease. Undoubtedly, the purpose is legitimate and the measure is adequate. However, in the past a prohibition of deboning was not uncommon for reasons of human health and keeping quality, which were also technically justified. It is difficult to predict which point of view will prevail in the future.

The dissatisfaction of meat exporters is understandable. However, the assumption is not justified that the veterinary profession is responsible for this situation. The international veterinary convention of 1935 stipulated that the national veterinary service should be under the authority of a Chief Veterinary Officer directly responsible to the Minister. If this were still the case, there would certainly be less fear of unpredictable changes of sanitary policy in the importing countries.

The technical feasibility of veterinary arrangements in the framework of multilateral commodity agreements has been questioned. A distinction should be made between the purely technical problems and the legal and constitutional problems involved. If common national veterinary legislation is possible in countries the size of the USSR and USA, despite local diversities within such countries, it can hardly be denied that common veterinary legislation is technically feasible for other large and diversified areas of the world. However, it is a different matter when one considers the constitutional right of sovereignty and the different legal frameworks and distribution of statutory powers within the various sovereign countries.

In this connection, reference must be made to a basic problem of veterinary legislation, a matter that should be obvious but whose significance very often appears to be not fully realized: animal diseases are a natural event, but legislation can refer to human action only. Veterinary legislation can and should prohibit actions that might favour the spread of animal diseases, and order actions that are expected to lead to the control and eradication of diseases. But it will always be an indirect approach: foot-and-mouth disease cannot be prohibited, and water cannot be ordered to be potable.

This determines the limits of the role that an agreed set of codes and standards may play in future multilateral arrangements. It should be clear that such a document alone cannot imply a guarantee that those who act in accordance with its precepts will automatically satisfy the requirements of the importing countries. In addition to agreeing upon fundamental preconditions, it will also be necessary to agree on the scope and modalities of inspections by veterinary officers of importing countries contractually authorized to be performed in exporting countries. There will be no major problems in authorizing foreign inspection in closed establishments, such as export slaughterhouses. But, with regard to the monitoring of field conditions and field services, problems of national sovereignty may arise. There may be discrepancies between the minimum extent of monitoring the importing countries would need in order to come to technically valid conclusions, and the maximum extent of foreign inspections the government of the exporting countries could constitutionally permit. This we assume would be the most difficult part of the negotiations. Once agreement has been reached on the modalities of cooperation, the codes and standards that have thus far been elaborated as guidelines and reference documents may serve as a basis for multilateral arrangements, but they will need to be revised in accordance with their new legal framework. Since it is unlikely that worldwide consensus will be reached on all details, a legally acceptable way of making exceptions will have to be found (possibly as supplementary protocols).

It must be emphasized in conclusion that although this article has discussed questions of the desirability and technical feasibility of a multilateral veterinary agreement, there is as yet no mandate from governments to elaborate any definite proposal. ■

The Red and Red-and-White cattle-breed comparison in Bulgaria

T. Hinkovski, A. Alexiev, B. Lindhé, and C.G. Hickman

The Bulgarian cattle industry is based primarily on the Bulgarian Red breed. The breed has a rather short history, having been created in the last few decades by crossing local breeds with the Danish Red. Earlier ancestors of the local breeds are Grey cattle, Red Sadovo (Sadovska) cattle, and different crosses of the Brown Simmental and Red cattle. The population of Bulgarian Red is located in northeast Bulgaria and the lowland part of the Plovdiv and Pazarjik districts. To animal geneticists and breeders of Red and Red-and-White cattle, the Bulgarian population of essentially Red cattle is increasing in importance. The average milk yield of recorded cows for 1975 was 4 015 kg. A corporation (headed by the senior author) controls approximately three quarters of the country's 800 000 cattle. It has made available 19 herds of Bulgarian Red cattle in six districts for an international strain comparison test. Seven foreign countries are supplying semen from Red or Red-and-White breeds for this test. The semen comes from a different group of 10 young bulls representing each breed in each of the 3 years of the project matings. The progeny of these matings started arriving in late 1977 and the early breeding and birth data are included in this report. A similar international strain comparison was established previously in Poland for the comparison of Black-and-White breeds and strains. Together, the two projects use young breeding bulls of the best Red and Red-and-White and Black-and-White breeds currently in artificial insemination (AI) service in the participating countries.

The Technical Advisory Committee (TAC) for the project consists of geneticists from the participating countries and FAO. This committee was represented recently by the junior authors on a tour of some of the herds studied in the project. One of the authors (Alexiev) is the project leader and has designed standard forms for use at all farms for collecting the required data. This article arose from this visit to the project and has been prepared not only to describe the project but also to illustrate a new era in cattle breeding research. Not the least of the benefits of such a project is the exchange of knowledge that occurs when the parties involved come together to discuss the design, operation and outcome of their international cooperative effort.

The original concept of using large institutional herds for these strain comparisons has already proved successful in Poland. This report emphasizes the Bulgarian project, however, because the first project justifies a separate presentation.

General description of the project. It was naturally impossible for the TAC representatives to see all the participating herds in the time available. Table 1 lists the participating farms and the number of milking cows at each (see also Figure 1). The daughter calves from these herds are regularly removed at 6 months of age to rearing centres where they are bred at 16 months of age, or 350 kg liveweight. Two months prior to calving they are moved to first-lactation milking barns. Although every attempt is made to ensure the same feeding and management at each rearing unit, it is likely that differences will exist in growth rate and breeding age. Thus, the identity of the rearing unit must be kept together with the milk records in order to adjust the yield measurements for any carry-over influence from the rearing environment.

Eight countries are cooperating in the project, including the host country. These are listed below along with the name of the breed from which semen was supplied and the members of the TAC for the project.

A supply of 200 doses of semen from each of 10 bulls is equivalent to a shipment of 2 000 doses from each country. Despite the long distances and varied airline connections, no trouble was experienced in the semen arriving safely at the "Tzentralna Stantzia za Iskustrem Osemeniavane," Sofia. This organization and each of its subsidiary district organizations are staffed with experts in semen evaluation and preservation. To date, the number of calves born per sire breed indicate that the final number of heifer calves produced would provide, without difficulty, the expected number of 150 heifers in their first lactations.

Some of the semen was below expected quality and, overall, the actual conception rate was only 42 percent. Compared with the regular national

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In the order listed, the authors' addresses are: General Director, Scientific Productive Institute for Cattle and Sheep, Kostinbrod, Bulgaria; Senior Scientist, The Buffalo Institute, Shumen, Bulgaria; Geneticist, SHS, Eskilstuna, Sweden; Animal Production Officer (Genetic Resources), Animal Production and Health Division, FAO, Rome, Italy. This project would not have developed had it not been for the farsightedness of Mr I. Mason and Prof. P. Ivanov. The diligent and continuous efforts of the animal care staff in Bulgaria are a major factor in the project's successful progress. Interested readers are invited to contact any of the TAC members for more information on this kind of genetic resource exploration.

Country	Breed	Country member of the TAC for the project
Bulgaria	Bulgarian Red	Dr A. Alexiev
Canada	Recessive red mutant of the Holstein-Friesian	Dr E.B. Burnside
Denmark	Danish Red	Prof. A. Neimann-Sørensen
Finland	Finnish Ayrshire	Dr K. Maijala
Germany, Fed. Rep.	RDR-Angler	Prof. H.O. Gravert
Norway	Norwegian Red	Dr O. Syrstad
Sweden	Swedish Red-and-White	Dr B. Lindhé
USSR	Estonian Red	Dr A.P. Beguchev
FAO Secretariat for the project		Dr C.G. Hickman

TABLE 1. **Farms included in the FAO International Breed Comparison in Bulgaria**

District [1]	Farm	Code	Number of milking cows
I Varna	Nicolaevka	1	300
	Mihalich	2	250
	Sullautsy	3	350
II Pazarjik	Pazarjik	4	500
	Glavynisa	5	100
III Ruse	Borissobo	6	350
	Novo sello	7	200
	Obrazlsov chiflik	8	250
	Shtruklevo	9	400
IV Silistra	Silistra	10	270
	Kalipetrovo	11	480
V Plovdiv	Trud	12	400
	Purvenets	13	350
	Iagodovo	14	400
	Orizarc	15	300
VI Shumen	Dibich	16	260
	Smiadova	17	180
	Madara	18	330
	Srednya	19	150
		Total	5 820

[1] 6 of a total of 28 districts in the country (see map).

average of 55 percent, this reflects adversely on the fertility status of the herds. This is clearly only part of the sacrifice the host country may have to face in conducting such research; there is also a considerable labour requirement for data collection, management control (called for by the experimental procedures), data processing and analysis. The regular staff in the Corporation, from the animal caretakers to the clerical help and their supervisors, absorbed this extra responsibility willingly and competently.

In return for the cost to the host country it must be recognized that there may be a gain in breeding quality of a lasting nature, which would be of incalculable benefit through the generations of descendants of the project animals. In the case of Bulgaria the assessment of this benefit awaits the results of the strain comparisons which in turn will affect the Government's policy on the relative emphasis on Red-and-White or Black-and-White cattle in the total composition of the national dairy herd.

Arrangement of strains across farms. There are many possible combinations for distributing bulls across farms and the basic principles of experimental design must be applied to eliminate any confounding with the most important factors to be estimated. However, herd design sometimes complicates operations to the point at which accuracy of recording begins to suffer. Good livestock research requires a balance between design sophistication and practical husbandry. This applies particularly to having semen available over long enough periods to allow return services with semen from the same bull. Likewise, the use of as few bulls and/or strains as possible at any one time keeps the recording error low. For this project, it was decided to use semen from only four strains at any one time and from all 10 bulls of each strain. This gave 40 different bulls in use at any one time out of a possible total of 80. Naturally, once the first four strains are used, the second four are shipped as soon as possible to reduce the possibility of strains and time effects being confounded. With this arrangement, all the bulls from each strain are used over the shortest period of time possible, thus giving maximum emphasis to an all-bull representation of the strains in each herd. Other possible designs could include all strains being used over the shortest period of time, each being represented by only a portion of the bulls in each strain. This would allow a degree of confounding among bulls with time but would minimize such confounding with strains. A great deal of theoretical information is available on experimental design but very few formal presentations exist for international animal breeding.

Genetic considerations. Granting that the design for the project is adequate, the critical consideration in this kind of experiment is: what do the estimates mean genetically? Discussions can be endless on this subject because the answer depends largely on the kind of inheritance for the traits being measured, which cannot be known in advance. Clearly, if there is non-additive genetic variability in the crosses, the results are less valuable

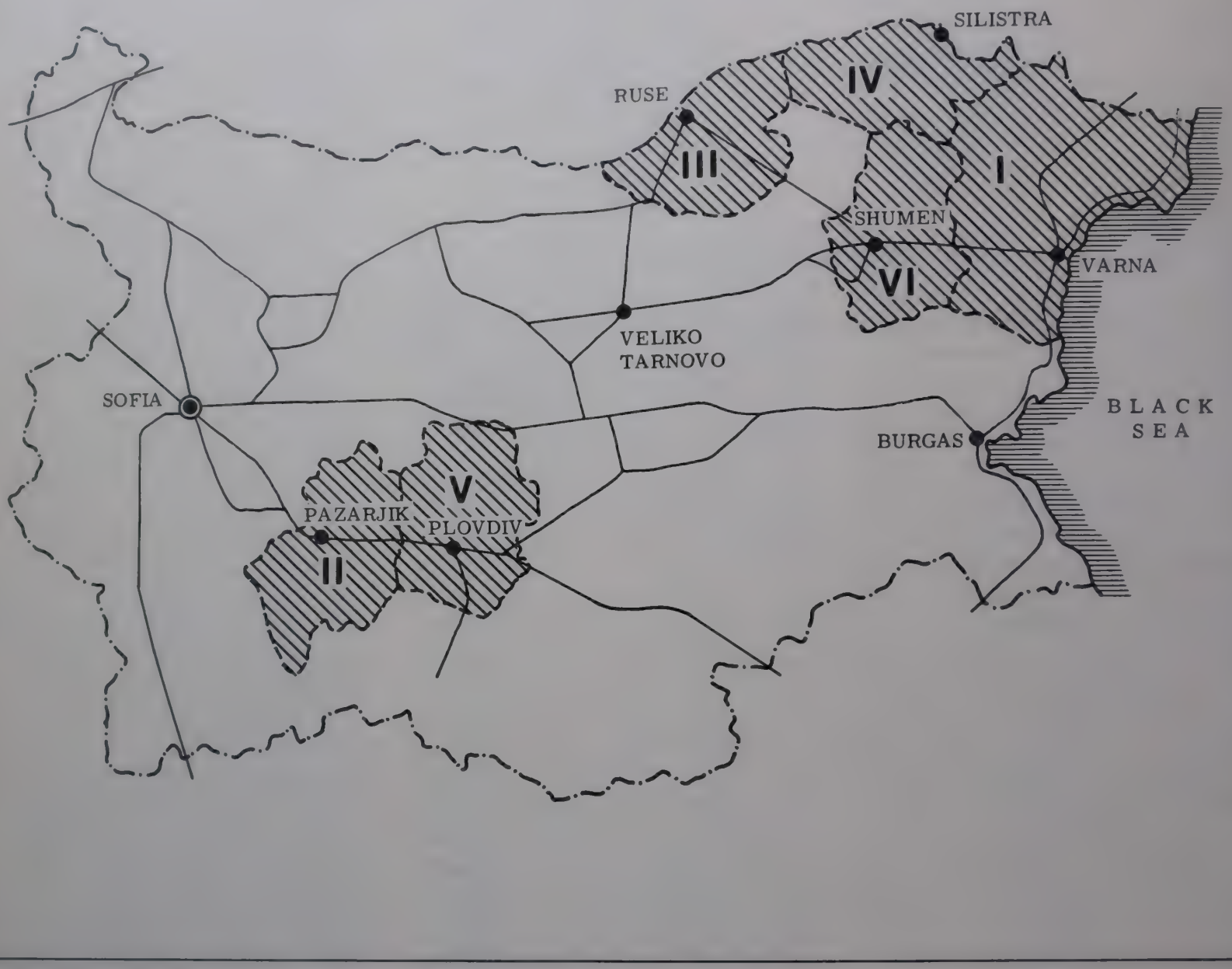

Figure 1. *Bulgaria: the provinces of the project (shaded).*

than if the differences were essentially genetically additive. The design of this experiment (see Figure 2) provides for an assessment of non-additive genetic variability in the results by using the original F_1 daughters as mothers to produce backcross daughters to bulls of the breed of their grandsire. There will be about 40 backcross daughters in each strain group and the difference in performance between these compared with that for their mothers will give an indication of the importance of non-additive genetic variability in the original daughters. This second-generation aspect of the experiment is particularly important because the Danish Red breed is more related to the Bulgarian Red than are

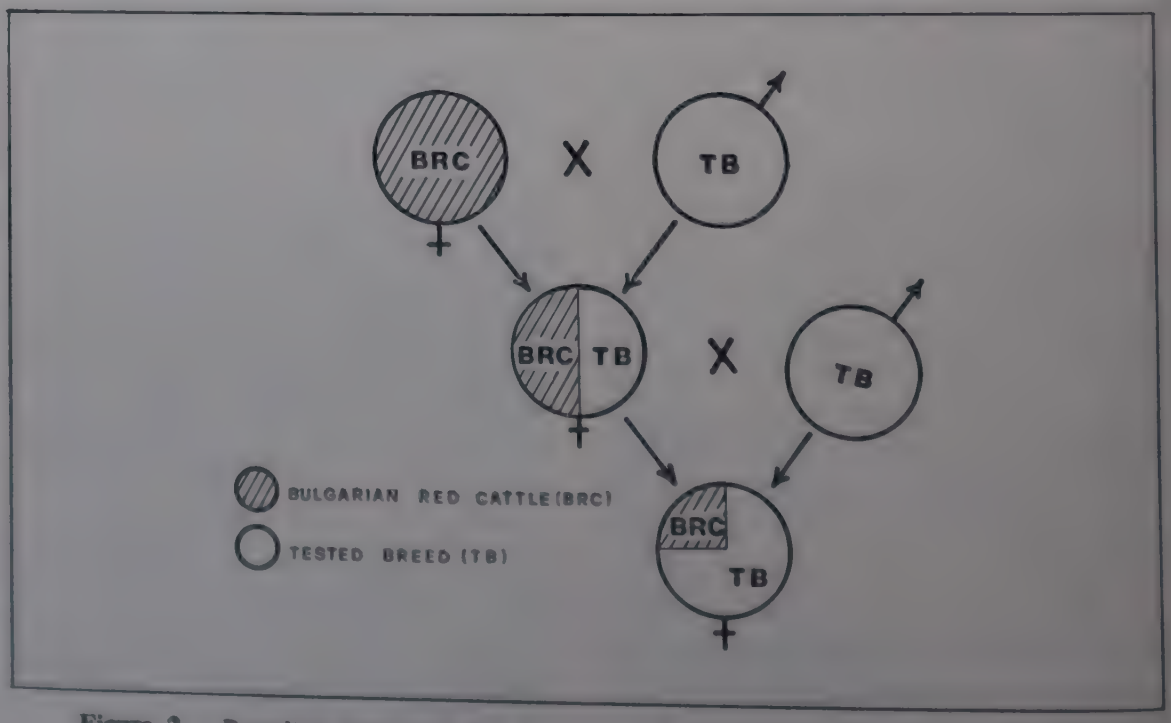

Figure 2. *Breeding plan for the Bulgarian Red-and-White breed comparison.*

Figure 3. *Progenies of different bulls, from left to right: Finnish Ayrshire, Swedish Red-and-White, Estonian Red, Norwegian Red, Canadian Red Holstein, Danish Red Angler and Bulgarian Red.*

the other strains and thus would have fewer different alleles in its test offspring.

Aside from the non-additive genetic variability the additive genetic effects also have some interesting sidelights. To estimate the additive differences between strains, it must be assumed that the bulls are representative of their breed. The 10 young bulls representing each breed were to be sons of "elite-proven bulls" and "chosen at random from among the young bulls entering artificial insemination." At this point one must admit that any experiment cannot be perfect. In some countries the AI population has a greater superiority over the average genotype of the national herd than in others. Similarly, the young bulls from which the 10 test bulls were chosen do not represent the AI population in the same way in every country that has a proven bull policy. That is, some countries have a better opportunity, or do a better job, of having large selection differentials for the sires and dams of young bulls entering AI. There is also the possibility that only some young bull groups accurately represent all the young bulls from which they were chosen. This can be accounted for by considering their final progeny test results but it must be clear that this kind of an experiment does not claim to be an accurate evaluation of the AI population of the participating countries or that of the national population from which the AI bulls are selected. The project will accurately rank the bulls by country of origin according to their offsprings' performance and thus give a good indication as to which bull source will give the greatest genetic change when used on the Bulgarian Red population.

Another important feature of the project is that 40 male offspring will be chosen at random each year from each sire-breed group for feedlot evaluation. At 4 months of age the male offspring are regularly taken to special fattening complexes (one per district) where they are fed intensively under uniform conditions. They will not be castrated and will be slaughtered at 450 kg liveweight, which they are ex-

pected to reach at about 14 months of age. Of each of these groups of 40 male offspring, 20 will be sectioned for complete carcass analysis. It is unlikely that Bulgaria will develop a specialized beef industry, but it is quite likely that an adequate, high-quality beef supply is possible from the dairy industry. This regular selection for milk and meat producing ability among the descendants of the project will go a long way toward establishing a sound livestock industry.

Summary of early data. The data collected to date have been summarized in Table 2; these foreshadow the full data potential of the project.

The average birth weight of the calves is 32.9 kg (31.6 kg for the female and 34.1 kg for the male). These first results show that there are not very big differences in birth weights of the calves that are progeny of the bulls of the different tested breeds. They vary on average from 32.2 kg to 33.4 kg (30.9 to 32.3 for female and 33.5 to 35.0 for male calves). Nevertheless, there is some tendency toward lower birth weights for the progeny of bulls from Angler, Norwegian and Finnish breeds.

Liveweight at 3 months of age for female calves is on average 97.6 kg. It varies from 92.2 kg for the progeny of the tested bulls from the Danish Red breed, to 99.7 kg for those from the Angler breed.

The first results show that in relation to the total number of calves born, the number stillborn was 3.3 percent. The lowest number of stillborn (0.7 percent) was in the Angler breed and the highest (5.3 percent) in the Danish Red. Pre-weaning mortality in calves was lowest among the progeny of Norwegian bulls and highest among those of the Swedish bulls.

As the experiment progresses, similar summaries can be made for milk yield and composition, first freshening weight and age, udder measurements, lactation length and milking ability. In addition to these data, the daughters will be recorded for disease, defects, accidents and mortality. Liveweights will be taken again at 6, 12 and 18 months of age and 24 hours after first calving. Age and liveweight at first oestrus will also be recorded. At least two stations will place a minimum of 10 heifers per breed on individual feeding trials and determine the protein content of their milk.

The final analysis of the data will be a gigantic task, not so much because there is a multitude of traits, but because each trait requires a complex analysis. Fortunately, the Institute at Kostinbrod has excellent computer facilities and all the data will be entered into the Institute's data bank. The major emphasis will be on the fact that the most important main effects in the design are the bull groups, which are fixed effects. Whether or not bulls within groups should be regarded statistically as fixed effects is a matter of conjecture. Since there may be non-additive genetic differences in the F_1 offspring, there is no easy justification for predicting future daughter production from that of daughters of the same bulls in the experiment. Prediction with minimum risk is the principal reason for considering main effects as random variables; this means that in this experiment bulls could also be considered fixed effects. The fact that bulls within breed groups may be genetically related can be ignored; they are a random sample from a population that they represent and they should therefore include prevailing relationships between individuals. Thus, all factors in the mathematical model may be regarded as fixed. Other important elements in the model will be farm within district, year/season, regression of yield on age of daughter, location of rearing within district, and other effects or interactions between effects that are considered important for each trait. The analysis and test of significance of all effects will require the latest computer techniques for matrix algebra and statistical analysis.

By agreement of all parties, the presentation of the results will be by approval of the TAC.

Figure 3 shows progenies of different bulls in the Shumen district.

TABLE 2. **Number of calves born and liveweight**

Breed of the father	Calves born alive					Birth weight (kg)			Female calves at 3 months of age	
	Total	Female		Male		Female	Male	Average	No.	Average liveweight (kg)
		No.	%	No.	%					
Bulgarian Red	146	63	43.2	83	56.8	31.6	34.5	33.2	40	94.2
Angler	141	84	59.6	57	40.4	30.9	34.0	32.2	70	99.7
Danish Red	107	50	46.7	57	53.3	31.4	35.0	33.3	44	92.2
Recessive red mutant of the Holstein-Friesian	133	72	54.1	61	45.9	32.3	33.6	32.9	51	98.6
Norwegian Red	116	58	50.0	58	50.0	31.2	33.5	32.4	44	98.1
Estonian Red	89	48	53.9	41	46.1	32.3	33.8	33.0	32	97.8
Swedish Red-and-White	97	45	46.4	52	53.6	31.8	34.8	33.4	29	98.5
Finnish Ayrshire	127	55	54.1	72	45.9	32.3	33.6	32.9	51	98.6
Total for the project	956	475	49.7	481	50.3	31.6	34.1	32.9	361	97.6

Summary. A few years ago FAO had to rely on national statistics for breed evaluations. Now comparative data are becoming available from the kind of international animal breeding research we have described. This article is intended to attract support for this kind of work so as to extend it to all species in all parts of the world. FAO, being primarily concerned with developing countries, should be kept informed on all genetic resources, such as the breeds being evaluated in this experiment. But eventually, and it is hoped in the not too distant future, it should be possible routinely to obtain comparative animal breeding data in developing countries. It is only by this means that an effective decision-making process can be established to guide a livestock industry into tested practices of improved efficiency. ■

Cassava as a swine feed

G. Gómez

Brazil, Indonesia, Nigeria, Zaire, India and Thailand are the six most important cassava-producing countries in the world in terms of total annual production (FAO, 1974). Brazil itself produces approximately one fourth of the world total. However it exports only 2 percent of its production, in contrast with countries such as Thailand, which exports 90 percent of the cassava produced, mainly to Europe.

Although cassava is essentially grown as a staple food, there is increasing interest in using the roots for animal feed. The development and application of efficient cultivation methods and production practices could increase cassava yields and alternative uses of cassava in the starch and animal feed industries would then become economic. The prospects for using cassava as an animal feed have been stimulated by the European Economic Community (EEC), where the replacement of high-priced cereals in composite feeds by alternative energy feedstuffs, such as cassava, has taken place (Coursey and Halliday, 1974; Phillips, 1974.)

Extensive experimental evidence has been obtained on the use of cassava in animal feeding programmes, a review of which was recently presented at the "Cassava as Animal Feed Workshop" (Nestel and Graham, 1977). The purpose of this article is to review some of the information regarding the use of cassava roots in swine feeding programmes.

Chemical composition of cassava roots and their products. Whole fresh cassava roots contain approximately 65 percent water and have to be dried or processed to extend their shelf life or to preserve them. Crude protein, ether extract, crude fibre and ash content are generally low in the fresh roots; the nitrogen-free extract (30-35 percent) or total soluble carboydrates are the second most important chemical constituent after water (Table 1). If cassava is not consumed fresh, the roots can be converted into stable dried products such as chips or pellets that can be subsequently used for industrial purposes or in composite animal feeds. Although all chemical constituents are concentrated in the dried cassava product, the most important component is starch, which accounts for 70 to 80 percent of its composition. Fresh chopped cassava roots can also be stored in airtight plastic bags or in trench silos but little is known about the chemical composition of chopped ensiled roots.

In addition to the routine chemical analyses, an analytical finding especially important for feeding programmes based on fresh roots is the cyanogenic glucoside content. Cassava varieties are normally classified as sweet or bitter according to their cyanide content; most of the hydrocyanic acid (HCN) or cyanide (CN) in roots, however, is found in the form of a cyanogenic glucoside known as linamarin. The concentration of linamarin is determined as the cyanide released from the glucoside when treated with dilute acids, but it is rarely quantified and reported. It appears that the cyanide level may be another factor responsible for some of the conflicting findings in trials. An enzymatic assay for the cyanide content of cassava that is more sensitive, more reproducible and faster than existing quantitative methods was developed recently (Cooke, 1978) and should be valuable in defining a more detailed classification of cassava varieties based on their cyanide content. No major problems have been encountered in feeding fresh, ensiled or dried cassava to pigs in Latin America because most of the cassava cultivars grown in this region have a low linamarin content.

Fresh roots in swine feeding programmes. Fresh cassava roots can be fed *ad libitum*, either separately or mixed with protein supplement. Pigs fed fresh sweet cassava and a protein supplement separately, through their growing (17-50 kg) and finishing (50-95 kg) periods, tended to consume more cassava (400 *v.* 380 kg/pig) and more protein supplement (115 *v.* 72 kg/pig) than those fed the chopped roots mixed with controlled quantities of

TABLE 1. **Chemical composition[1] of fresh chopped, dehydrated cassava roots (meal) and ensiled roots**

Chemical components	Fresh roots	Meal	Root silage
	(percent-fresh-weight basis)		
Water	60-65	10-14	57
Crude protein (N × 6.25)	1-2	3-4	2.3
Ether extract	0.2-0.5	0.6-1.0	1.5
Crude fibre	0.8-1.0	3-4	1.9
Nitrogen-free extract	30-35	70-80	34
Ash	1-2	2-4	3.4

[1] Range of values commonly found in cassava products used for swine-feeding experiments at CIAT. Roots are normally obtained from 10- to 12-month-old cassava cultivars grown at the Centre.

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protein (43 percent crude protein) supplement (Buitrago, 1964). The basic difference in feed intake was the amount of protein supplement saved when it was mixed with chopped fresh cassava; however, the extra labour required to do the mixing could outweigh the advantage of this method.

The consumption of chopped fresh cassava by growing-finishing pigs varies according to the protein content of the supplement. The daily intake of cassava throughout the growing-finishing period was greater when the protein supplement (fed free choice) supplied higher protein levels (Figure 1) and at the same time the intake of the supplement decreased. Although performance of pigs fed fresh chopped cassava was similar to or better than those fed a control diet, a tendency to overconsume protein was observed as the protein content of the supplement increased (Table 2).

Fresh sweet roots are also readily consumed by gestating and lactating gilts or sows when an adequate supplement provides a good source of protein, minerals and vitamin. Although experimental data on the use of fresh sweet roots during gestation and lactation periods have been satisfactory, the sows on this diet had a slightly inferior litter performance than the control diet-fed sows (Maner, 1972). More information is needed to make the most efficient use of fresh roots throughout the reproductive periods of the swine life-cycle.

Experimental information obtained at the Centro International de Agricultura Tropical (CIAT) and the Instituto Colombiano Agropecuario (ICA) in Colombia on the use of fresh sweet cassava throughout the different periods of the swine life-cycle is summarized in Table 3. Pigs fed fresh chopped sweet cassava with a good quality protein supplement performed satisfactorily; a mixture of plant and animal protein, when possible, seems to be advisable because the quality of the protein supplements may affect the intake of fresh cassava by growing pigs.

Pigs do not readily consume fresh bitter roots. When a protein supplement was supplied *ad libitum* with chopped, fresh bitter roots, the pigs consumed an excess of the supplement to compensate for the limited intake of the bitter roots. However, when the fresh bitter roots were thoroughly mixed with the protein supplement, they were not consumed in sufficient quantities to meet maintenance requirements and the pigs lost weight during the experimental period (Gómez, Camacho and Maner, 1976).

Experimental results obtained during the different periods of the swine life-cycle suggest that fresh sweet roots are an excellent source of energy for swine feeding programmes when properly supplemented with protein, minerals and vitamins. Figure 2 shows the total amounts of fresh chopped cassava and of a soybean meal-based protein supplement (40 percent crude protein)

TABLE 2. **Performance of growing-finishing pigs [1] fed fresh sweet cassava and a protein supplement (PS) free choice**

Parameter	Control diet	Fresh sweet cassava +		
		20% PS	30% PS	40% PS
Daily gain (kg)	0.63	0.70	0.67	0.65
Daily feed intake (kg)				
Fresh cassava	—	1.78	2.74	3.32
Protein supplement	—	1.39	1.00	0.75
Total feed (10% dry matter)	2.08	2.08	2.07	2.04
Feed/gain	3.30	2.97	3.09	3.14
Protein in diet (%)	14.3	14.6	16.6	17.3

Source: Job (1975).
[1] Mean of five individually fed pigs per treatment: average initial weight 21.1 kg; 98-day trial.

TABLE 3. **Life-cycle feeding programme based on fresh sweet cassava**

Period	Bodyweight (kg)		Total intake/ animal (kg)		% CP in PS
	Initial	Final	Cassava	PS	
Growing-finishing (98 days)	17.5	99.5	397	[1] 115	43
		95.6	381	72	43
	21	86	175	[1] 136	20
			269	[1] 98	30
			325	[1] 74	40
Pre-gestation (60 days)	95	Breeding (120)	[2] 240	[2] 36	40
Gestation (114 days)	Breeding	Farrowing (150-160)	[3] 194	[3] 46	40
			[4] 353	[4] 71	40
Lactation (56 days)	Farrowing	Weaning (140-150)	364	68	40

[1] Protein supplement was fed separately from cassava; in all others, supplement was mixed with chopped cassava. — [2] Estimated values based on daily intake of 4.0 and 0.6 kg of cassava and PS, respectively. — [3] Sows kept on pasture lots were fed daily 1.7 and 0.4 kg of fresh cassava and PS, respectively. — [4] Sows kept in confinement were fed daily 3.1 and 0.6 kg of fresh cassava and PS, respectively.

Limited information is available on the effect of cyanogenic glucosides found in bitter varieties when fed to pigs during the reproductive periods. More information is needed on the use of fresh bitter varieties during these periods, but apparently the placental barrier plays a significant role in preventing toxic effects in the growing foetuses.

normally consumed per pig throughout the different periods of the swine life-cycle.

Handling of feeding programmes based on fresh sweet cassava is an important aspect to be considered. A chipping machine such as the Malaysian model (Figure 3) is better than other models because it reduces to a minimum the loss of starch in the

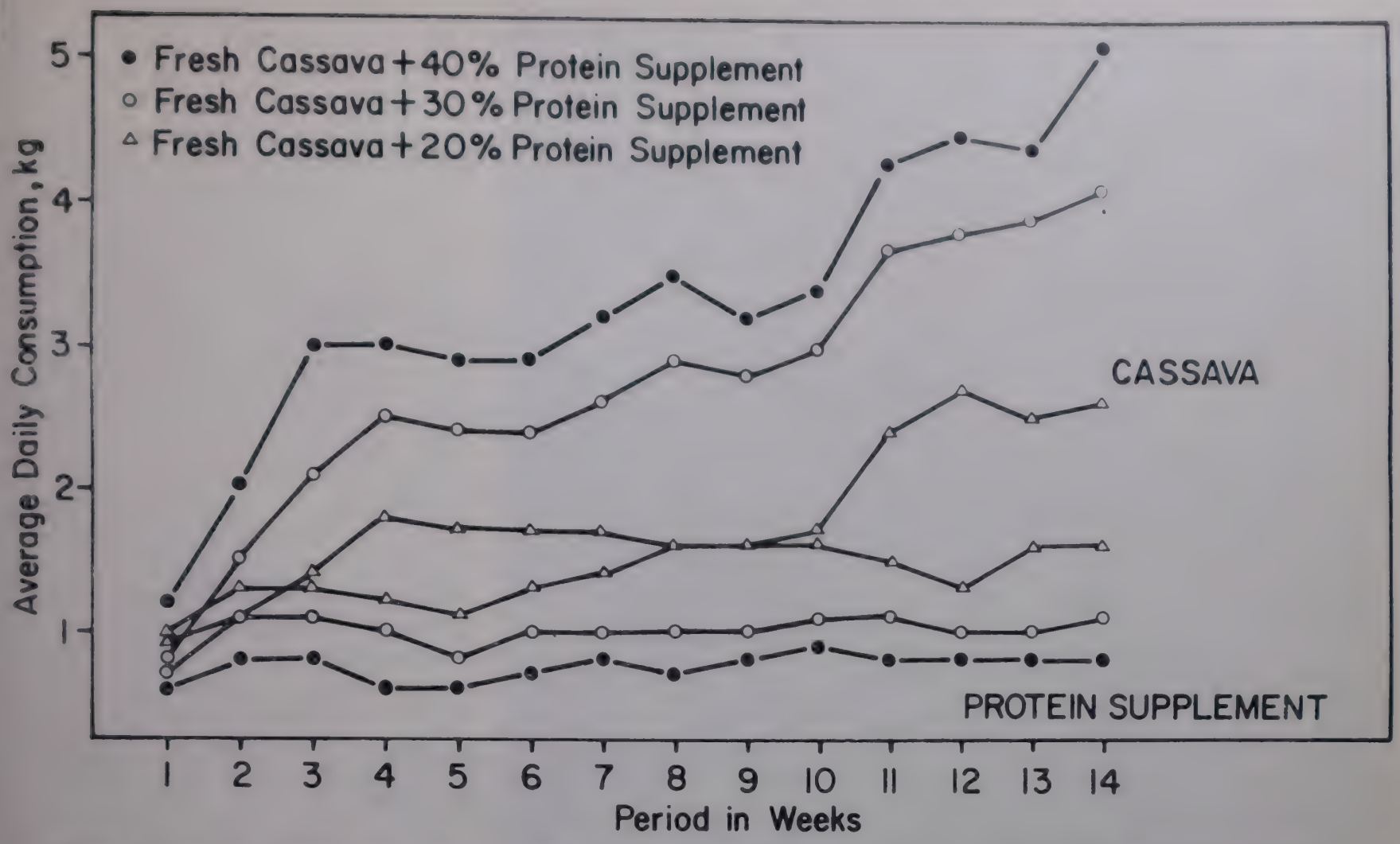

Figure 1. *Average consumption curves of pigs fed cassava and either 20, 30 or 40 percent protein supplement free choice.*

chipping process and pigs consume the chips more readily than they do ground fresh roots.

Self-feeding systems based on the separated, *ad libitum* consumption of fresh chopped roots and protein supplement usually lead to excess intake of the supplement, resulting in a significantly higher daily protein uptake than the recommended requirement. A controlled supply of chopped sweet cassava mixed with protein supplement would restrict the excess protein consumed to normal levels, but the additional labour required must be taken into account. During the reproductive periods of gestation and lactation, it is always best to use a controlled individual feeding system. Unfortunately, there is no information available on the use of fresh sweet cassava during the consecutive gestation and lactation periods. It is assumed that no major detrimental effect will be encountered when a feeding system is based on the continuous use of fresh sweet cassava; however, more information is needed, especially with regard to the lactation period.

Life - cycle swine - feeding using sweet cassava meal. The most convenient and practical way of handling cassava is to dry the chopped fresh roots and grind them into a meal, which can be easily incorporated into composite diets. In most of the experimental work at CIAT, cassava meal has been obtained from sweet varieties, mainly *Llanera*. The roots are chopped and sun-dried, either on cement floors or on wood-framed trays with mesh bottoms (Figure 4). Cassava meal can be stored in a well-ventilated area for a long time without deterioration in its nutritive value. Cassava meal is an excellent energy source of nutritive value because of its highly digestible carbohydrates (70-80 percent), mainly in the form of starch; however, its protein content (2-4 percent) is low.

A life-cycle swine-feeding programme based on sweet cassava meal (60-70 percent) was undertaken at CIAT. Experimental diets followed the recommendations of the US National Research Council (1973) for the different periods of the life-cycle. The feeding programme based on sweet cassava meal was simultaneously compared with a control feeding programme based on common maize. For both programmes, soybean meal was used as the protein source to balance the diets. Detailed information on this work has been published elsewhere (CIAT, 1976, 1977; Gómez, Camacho and Maner, 1976).

In general, gilts fed the sweet cassava meal grew more slowly than the control animals (0.77 *v.* 0.71 kg/gilt/day, from 20 to 90 kg bodyweight). The number and weight of the live-born baby pigs were similar for both experimental groups, although a trend toward fewer and lighter baby pigs per litter was observed for the gilts in the cassava-meal feeding programme. At 21 days of age and thereafter, the number of suckling pigs per litter was significantly ($P < 0.05$) inferior, by approximately three pigs per litter, for the lactating gilts in the cassava feeding programme (6.6 *v.* 9.4) compared with the control group. A similar trend had been previously reported in feeding swine with fresh cassava or cassava meal during either the gestation or lactation periods (Maner, 1972). From

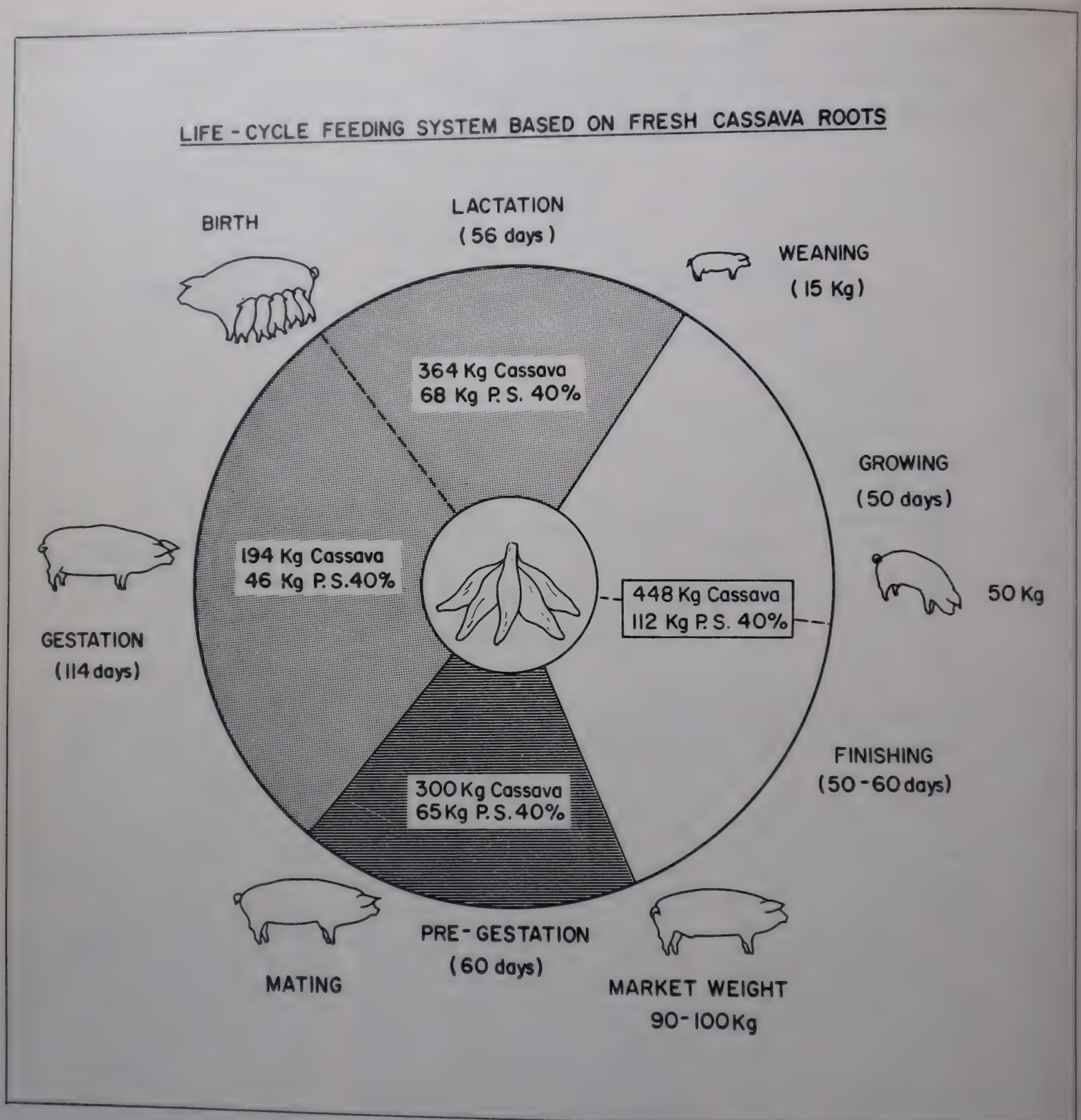

Figure 2. *Life-cycle feeding system based on fresh cassava roots and protein supplement (P.S.).*

the production point of view, the most striking difference was the significantly lower number of weaned pigs in the cassava feeding programme.

Methionine supplementation is usually recommended when high levels of cassava are mixed in composite diets with plant protein sources such as soybean meal. Apparently methionine serves the double purpose of improving the protein quality of the diets and of supplying a readily available source of labile sulphur for cyanide detoxication (Maner and Gómez, 1973). However, the absence of methionine supplementation in the life-cycle feeding programme does not appear to be responsible for the lower reproductive performance of gilts in the cassava-meal feeding programme. The results of recent experimental work (CIAT, 1977) in which sweet cassava meal soybean meal-based diets were fed throughout the gestation and lactation periods, with and without methionine, showed that gilts fed cassava meal performed similarly, irrespective of the methionine supplementation (Table 4). The experimental period in this study was initiated at breeding whereas in the

life-cycle experiment selected gilts started the experimental feeding programme when they weighed approximately 20 kg. Furthermore, experimental results (CIAT, 1977) on the supplementation of methionine (0.2 percent) in diets based on cassava meal for growing-finishing pigs in combination with either soybean meal or cottonseed meal indicated that methionine was not indispensable and did not improve pig performance.

Data on intake of the experimental diets and the basic ingredients recorded in the life-cycle swine-feeding programme based on cassava meal are presented in Table 5. Overall total intake of experimental diets and intake for individual periods were similar for both groups. The most important difference was the amount of soybean meal required for the cassava-meal feeding programme compared with the maize-based feeding programme. Almost twice as much soybean meal is required for the growing-finishing periods and approximately 60 percent more for the reproductive periods in a feeding programme based on sweet cassava meal compared with a feeding programme based on common maize. The economic feasibility of using cassava as a substitute for conventional energy sources would depend not only on the relative price of cassava but also on the price of protein supplements needed to balance cassava-based diets.

Cassava root silage as a swine feed. Although the most practical way of handling cassava roots is to dry the chopped roots and grind them into a meal, it is not always possible to air and sun-dry cassava in humid tropical areas. Under these circumstances cassava roots can be used fresh, stored or ensiled. Cassava roots can be stored in field clamps and preserved for at least 2 months without any marked decrease in their nutritional quality, especially when processed for the production of cassava meal (Booth *et al.*, 1976). Another way of preserving cassava roots is to store them in airtight plastic bags or in a trench silo (Figure 5).

Little information is available on the ensiling process and on the nu-

Figure 3. *A Malaysian chipping machine used for processing fresh cassava roots at CIAT.*

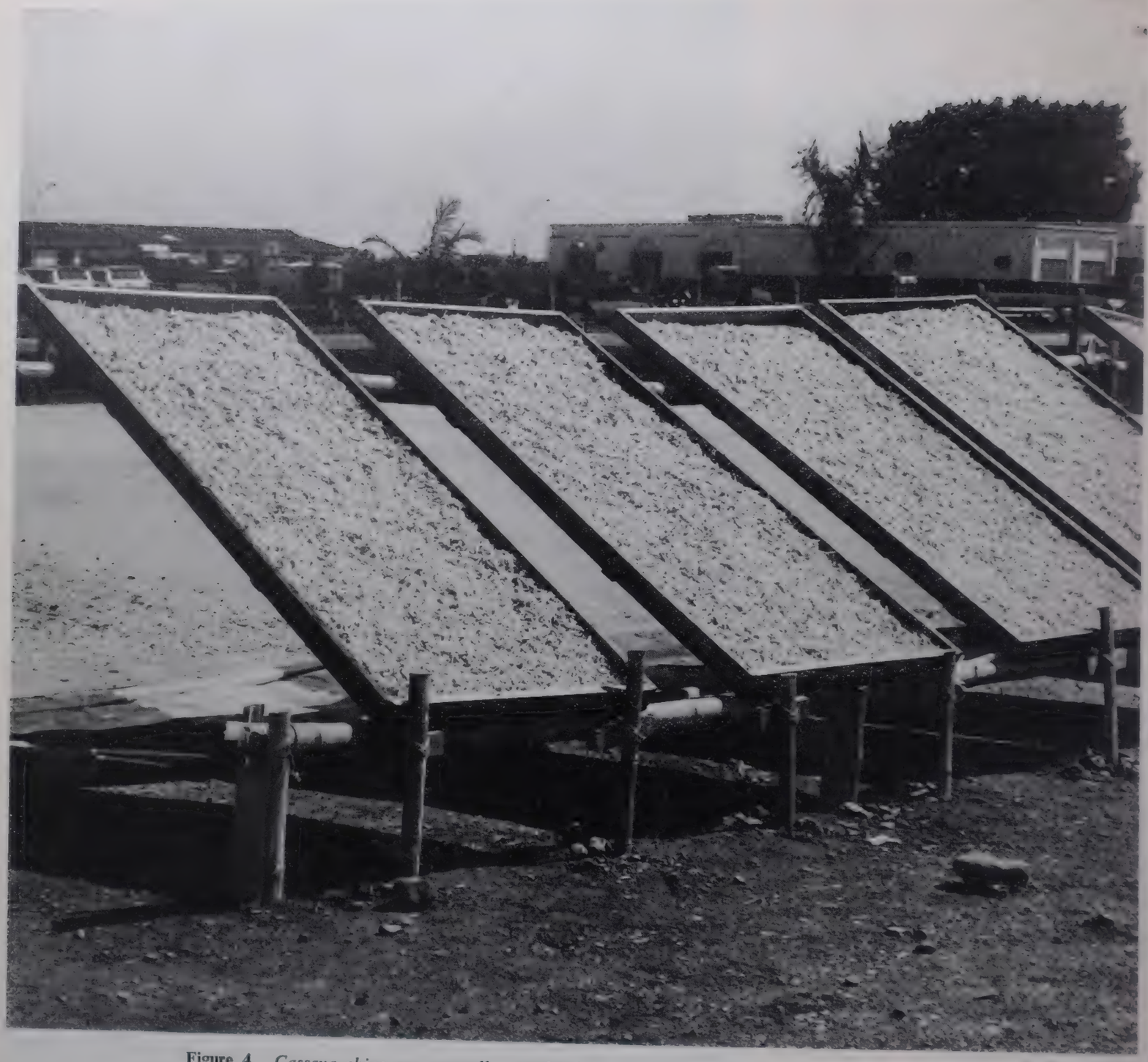

Figure 4. *Cassava chips are normally sun-dried on wood-framed trays with a mesh bottom.*

TABLE 4. **Effect of methionine supplementation in diets based on sweet cassava meal for gestating-lactating gilts**

Parameter	Common maize	Cassava meal + soybean meal	
		0.0% DL-Met	0.3% DL-Met
No. gilts farrowed	14	10	10
Data at farrowing			
No. pigs/litter	8.5	9.1	9.4
Average pig weight (kg)	1.09	1.06	1.07
Data at weaning (56 days)			
No. pig/letter	7.1	8.2	8.0
Average pig weight (kg)	16.74	16.15	16.54
Total litter weight (kg)	117.02	128.50	131.95

Source: CIAT [illegible]

tritive quality of the stored product. Roots kept in airtight plastic bags were readily consumed by growing pigs; daily consumption of root silage (3.8 kg) was similar to that of fresh chopped cassava (4.0 kg) and the protein supplement intake for either ensiled or fresh cassava was also similar (1.0 kg day/pig). The daily gains of growing-finishing pigs (18.3 to 99 kg body weight) were 0.75 and 0.77 kg, for the ensiled cassava- and fresh cassava-fed pigs, respectively (Maner, 1972). Ensiling the whole plant decreased the quality of the product and

Figure 5. *Chopped cassava roots can be satisfactorily stored in trench silos as shown in the picture or in airtight plastic bags.*

reduced the acceptability of this silage by the growing pigs. The performance of the pigs fed the ensiled whole plant was inferior (0.64 kg/day) to that of pigs fed roots.

Experimental work in progress at CIAT suggests that cassava roots can be ensiled for as long as half a year and still be readily consumed by growing pigs. A total of approximately 390-400 kg of ensiled roots and 90-93 kg of a 41 percent protein supplement was required to reach market weight (96 kg). The protein supplement was mixed daily to ensure ade-

TABLE 5. **Intake of experimental diets and basic ingredients in life-cycle feeding programmes based on sweet cassava meal or common maize**

(Kilograms)

Parameter	Periods			
	Growing-finishing	Pregestation-gestation	Lactation	Baby pig starter
Feeding programme based on				
Common maize				
Total diet	215.8	440.5	265.5	79.6
Maize	180.7	363.1	202.8	49.8
Soybean meal	24.8	56.3	49.9	18.1
Sweet cassava meal				
Total diet	215.9	428.2	292.5	51.1
Soybean meal	157.7	310.9	196.0	25.9
Cassava meal	47.8	96.8	82.8	17.7

Source: Gómez (1977).

quate supplies of protein, minerals and vitamins. Roots ensiled in a silo appear to be acceptable in combination with different protein supplements.

Economic considerations. Most of the cassava produced in Latin American countries is consumed as human food and little is used as animal feed. Under normal circumstances good quality roots are too expensive to be used as animal feed; however, a large proportion of the roots are fed to animals, especially to pigs, at the small-farm level. An important alternative use of cassava roots is the starch market; and in the process of starch extraction from cassava, some by-products are obtained that are used as animal feed.

At present some European countries are using chips or pellets, imported mainly from Thailand, in animal feeding. Least-cost feed rations with varying prices of cassava and other feed ingredients have been estimated for different animal species by several EEC importers of cassava (Phillips, 1974). High levels of cassava meal, in the range of 40 to 60 percent of the ration for growing and fattening pigs, were commonly used when the price of dehydrated cassava varied from US$65 to 90 per metric ton (Phillips, 1974). The price of Thai cassava root pellets during 1977 was about US$80 per metric ton at Bangkok and the c.i.f. price at Rotterdam fluctuated within the range of US$95 to 110 per metric ton during the same period (KKU-IDRC, 1977).

The commercial production of cassava root chips or pellets in most Latin American countries is still insignificant. The market price of fresh roots in some cassava-producing areas of Colombia varies from US$50 to 100 per ton, which is too high to be considered for animal feed. Little information is available on the market price of cassava in tropical areas, but undoubtedly the price of roots there is significantly lower. The prospects of increasing cassava production by application of the technology developed by the cassava programme at CIAT suggest that cassava roots could become an important energy ingredient for animal feeding in several countries in Latin America.

Summary. Cassava roots are an excellent source of dietary energy and can be used as fresh, dried or ensiled products in swine-feeding programmes. Fresh, chopped, sweet cassava roots can be fed to pigs throughout their life cycle, either separately or mixed with a protein/mineral/vitamin supplement. Fresh bitter roots, because of their high linamarin content, are not readily consumed by pigs.

High levels of cassava meal (60 to 70 percent) have been tested at CIAT and compared with a conventional, common maize life-cycle swine-feeding programme. Litter performance at weaning was inferior for the gilts fed the cassava-meal diets to those fed the diets based on common maize. Methionine supplementation does not appear to be indispensable in diets based on cassava meal/soybean meal.

Whole cassava roots can be stored in field clamps and chopped roots can be kept in airtight plastic bags or in a trench silo without significant loss of their nutritive quality as animal feed. Roots ensiled for up to 6 months are readily consumed by growing pigs.

Because of their low protein content, feeding programmes based on the use of high levels of cassava require a considerably larger supply of protein supplement than conventional energy sources such as cereal grains. ■

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Animal production in the arid zone of Australia

V.R. Squires

Figure 1. *Australia's arid zone is a vast continuous area that encompasses every mainland state except Victoria, and supports about 35 million sheep and 4.5 million cattle.*

Australia is about the size of the continental United States but has a larger arid zone. About 74 percent of the total land surface can be classified as arid or semi-arid. All of this area is in the inland regions and encompasses every mainland state except Victoria.

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It is one large continuous tract embracing 5 700 000 km² (about one third the size of the Sahara) and stretches about 3 000 km from east to west and about 2 000 km from north to south (Figure 1). About half of the arid area, mostly in the west, consists of sand plains or dune fields considered unsuitable for grazing because of their unpalatable and unnutritious vegetation (Figure 2). The remainder supports about 4.5 million cattle (about 22 percent of the national herd) and about 35 million sheep (about 20 percent of the national flock).

In inland Australia the pastoral industries are wholly dependent on the natural pastures (rangelands) and forage they provide. The rangelands of Australia were among the first of its natural resources to be put to beneficial use by man. Long before the discovery of gold, the forage on its inland plains was beginning to form the basis for a reliable economy. Utilization of semi-arid and arid rangelands has constituted a major sector of the country's economy.

The history of occupation of these pastoral lands shows that, beginning less than two centuries ago, immigrants came to various coastal locations, from

which they spread, with their flocks and herds, inland in decreasing densities toward the arid interior. The occupance of the non-desert areas was accomplished fairly quickly. By the start of the twentieth century the pattern was fully established. Settlement since that time has been involved mostly with intensification rather than expansion.

The arid and semi-arid lands have resources that offer the pastoralists a very restricted range of enterprise options. Climatic, biological and economic factors virtually restrict rural production to the conversion of native forages to meat or fibre by ruminant livestock.

Unreliable climatic conditions represent an overriding influence in the arid zone and have led to the development of a system of livestock grazing and marketing that is adapted to cope with them. Recent events, however, involving sudden and unpredictable falls in the price of wool and, more recently, beef cattle, lead one to conclude that, despite a long-standing demonstrated capacity to cope with the effects of seasonal variation, pastoralists in the zone are not as well equipped to deal with the very large income fluctuations that result when prices for produce become depressed by changes in world markets. The sudden closure of markets for beef overseas has severely restricted the cattle managers in their option of controlling herd size through management of volume of sales. With restricted (in some cases zero) sales from remote arid-zone properties, herd size and grazing pressure have risen to unprecedented levels. Increased livestock numbers will bring greater pressure onto the rangeland resource, and may involve a run-down of the resource base.

It is against this background then that this article will consider the potential for increasing animal production in the arid zone of Australia and the outlook for the future.

The climatic factor

Australia has the unenviable distinction of being the world's most extensive arid continent. The low average annual rainfall is associated with a high variability. This is illustrated by the cattle numbers and rainfall in the Alice Springs district of central Australia over the past 30 years (Figure 3). This variation is normal for the arid zone. Drought is a recurring feature of Australia's pastoral zone and is both unpredictable and can be severe.

Rainfall characteristics determine to a large degree the type of livestock that can be successfully raised. There are three broad regions: areas in the north with summer rainfall, areas in the south with winter rainfall, and a large belt in between with no clear season of most rain. The summer rainfall areas are usually grazed by cattle and the other areas by sheep although there has been some shift of cattle into the traditional sheep areas

Figure 2. *About half of Australia's arid zone is unsuitable for grazing because of the unpalatable and unnutritious vegetation. Spinifex* (Triodia basedowii), *a tough, fibrous and spiny grass, covers many of the dunes and sand plains. Sandhill cane grass* (Zygochloa paradoxa) *occurs as scattered clumps on the sand dunes.*

over the past few years. As Figure 4 shows, the reality is less tidy than the generalization would suggest.

Economic and political factors

Not only has there been a swing from sheep to cattle production in some areas of the pastoral zone but other, more serious, changes have taken place. Economic changes, population shifts, competition for land, the cost/price squeeze, depressed land values — these and other factors are altering the social and political status of arid-zone pastoralists.

For instance, in 1976 the arid zone carried 20 percent of Australia's sheep and 22 percent of its cattle. In the same year it produced 82 percent of Australia's copper, 95 percent of its lead, 93 percent of the iron ore and 28 percent of the natural gas. Urban prosperity is now less dependent on rural income and on the livestock products of arid and semi-arid regions than ever before. What is critical to the future of arid-zone land management is that rangeland livestock industries are currently in a severe and enforced adjustment period at a time when rural and urban economic systems are obviously uncoupled.

Many producers have reached an irrecoverable economic situation because of recent and current economic crises and will leave the industry. The remaining hard core of producers will survive according to their ability to effect economies or increase efficiency.

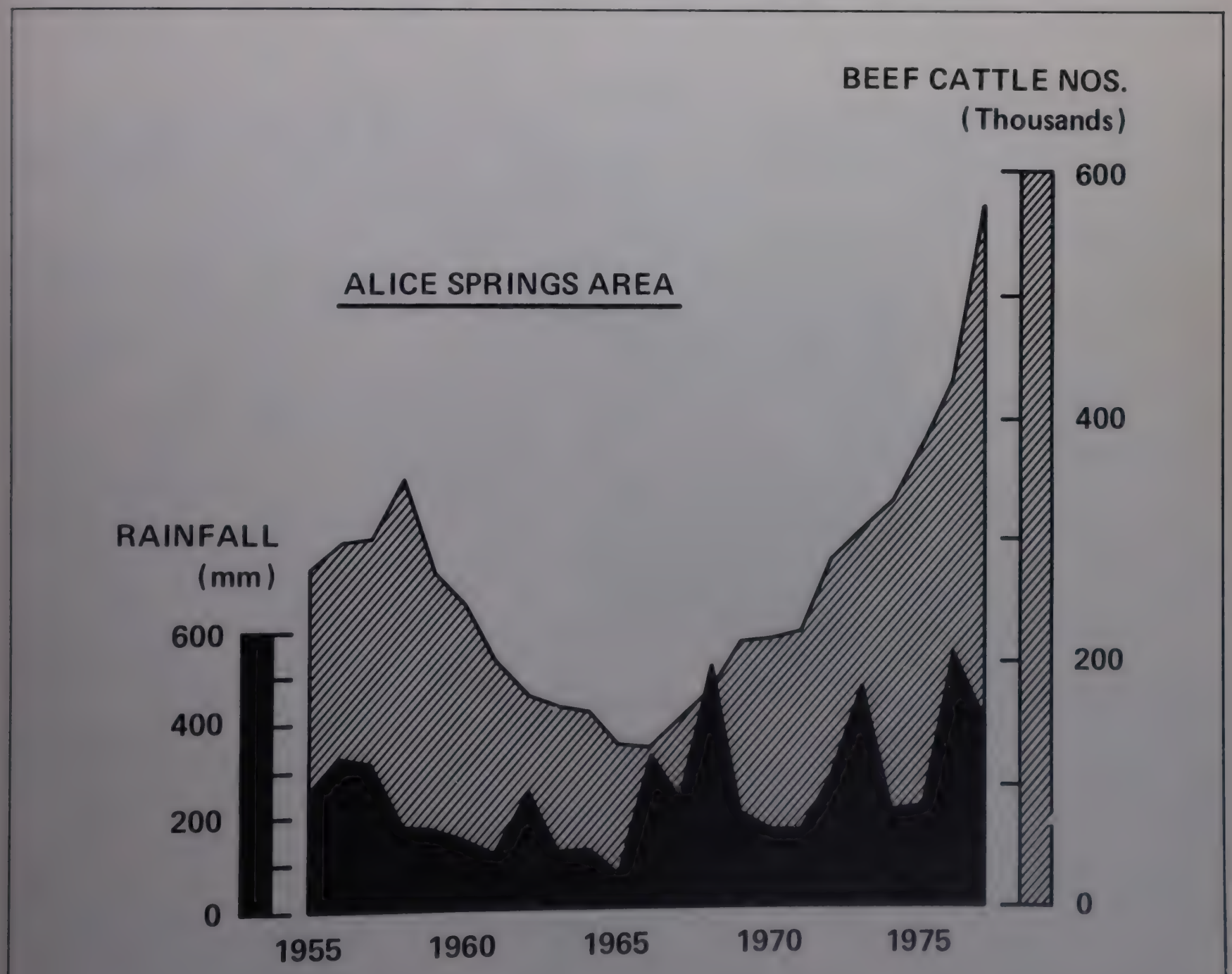
Livestock industries

The principal livestock in the inland regions of Australia are sheep (Figure 5) and beef cattle (Figure 6) and the main products are wool and beef.

Australia produces about 30 percent of the world's wool, twice as much as the USSR (the second largest producer), and wool is the most important rural export. Although Australia is also a major producer of beef and veal it produces only one third that of Argentina and about one tenth that of the USA.

Sheep industry. Australia has the largest sheep industry in the world. More than three quarters of the sheep are bred and kept for apparel wool,

Figure 3. *Australia's arid zone is characterized by marked fluctuations in rainfall.*



most of which is exported. In 1970 there were 180 million sheep in Australia producing 923 000 tons of greasy wool but numbers have since decreased with a corresponding decline in wool production. Sheep numbers in the arid zone have been fairly static while numbers in the humid fringe have increased.

Most of the sheep in the arid areas are run on large properties where capital and labour components are low compared with those in the humid fringe (see table). The industry covers about one third of the continent but directly employs or supplies a living for less than 5 percent of the population.

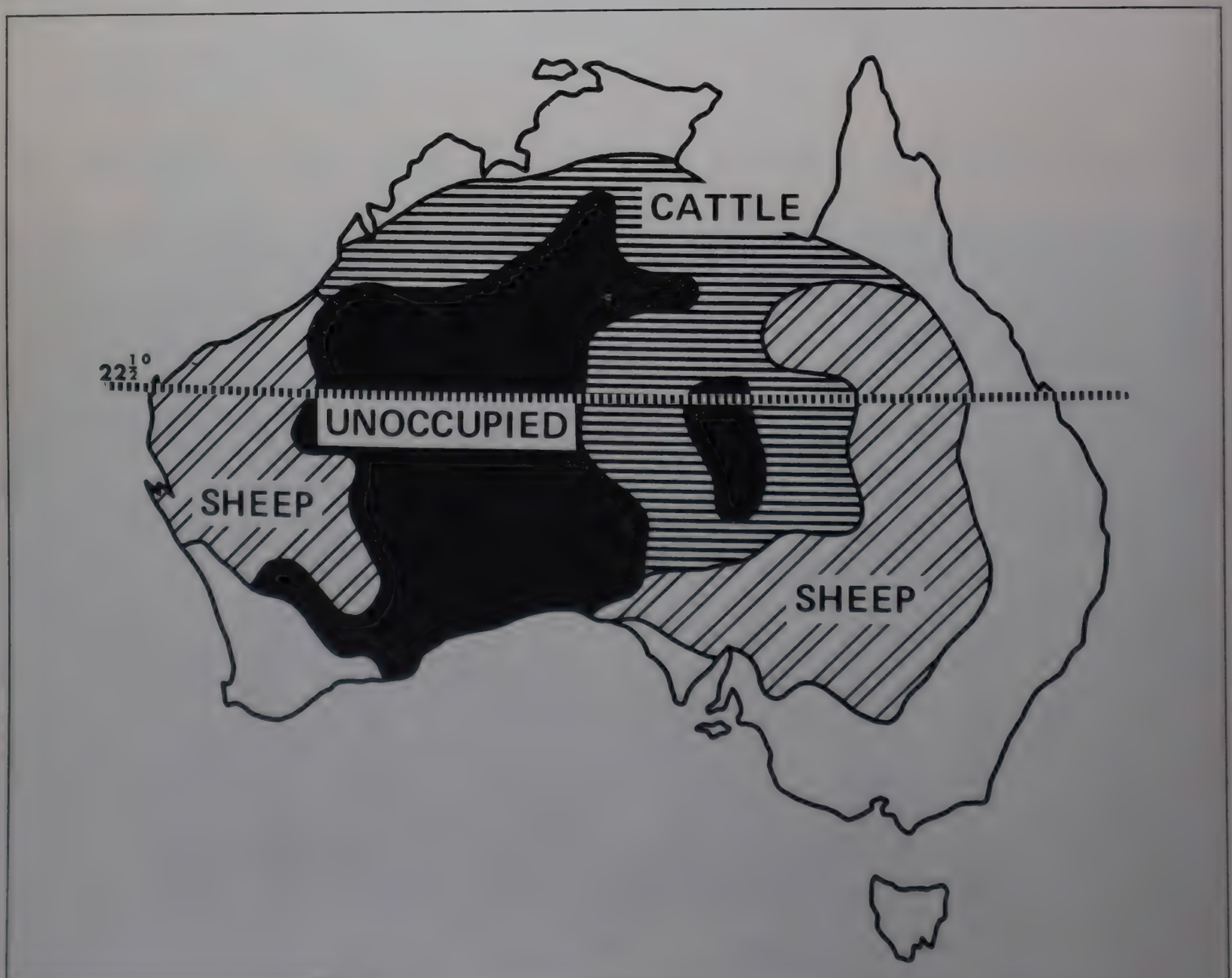
The sheep industry is dispersed throughout inland Australia and encompasses a wide range of environmental conditions with annual rainfall ranging from less than 250 mm to more than 400 mm. The Merino flocks are found throughout the sheep-grazing areas of Australia and although wool is their major product some of these flocks provide ewes that form the foundation of the prime lamb industry. The Merino sheep has, through selection over the past 150 years, developed varieties suited to hot-dry environ-

Selected Australian arid-zone sheep and cattle statistics

Type of enterprise	Property size (ha)	Herd/flock size (No.)	Total capital invested ($A) [1]
Cattle-dominant			
Queensland	24 140	1 070	380 800
Northern Territory	433 400	7 480	1 436 000
Sheep-dominant			
South Australia	112 200	3 870	288 100
New South Wales	10 770	3 800	286 780

[1] $A1 is roughly equivalent to SUS1 (1978).

Figure 4. *Distribution of sheep and cattle enterprises within Australia's arid zone shows some relationship to climate. Cattle predominate in the north, which has a predominance of summer rainfall.*



ments. In hot-dry and summer-rainfall country the Merino is low in production (3-5 kg greasy wool) and in fertility (30-50 percent of lambs a year).

Within the arid zone there are regional differences in sheep productivity. The average greasy-fleece weights of sheep in the northern subtropical areas of eastern and western Australia are considerably lower than those of sheep in the temperate semi-arid southern areas (Figure 7). Similar north-south trends are apparent in lamb marking percentage in eastern Australia but are not apparent in western Australia. The low productivity of sheep in northern Australia must impose a severe economic penalty on those pastoralists in these areas, where there are about 6.5 million sheep that produce less than 2.5 kg of clean wool per sheep per year.

The last 30 years have been a dynamic period for the Australian sheep and wool industry in that there have been great changes in population and production characteristics. During this time-span the industry has experienced mixed fortunes, ranging from the buoyant conditions of the early 1950s to those at present where it is being subjected to strong economic pressures. Changes in marketing structure to include a guaranteed minimum return (floor price), sale by sample, and objective measurement techniques could help reduce the effects of the cost/price squeeze.

Beef cattle industry. The beef cattle industry is a major industry with the gross value of its products of the same order as the value of the wool clip. Australia is usually second to Argentina in beef exports; 40 percent of the beef and veal produced is exported, mainly as boneless beef.

Beef cattle are widely distributed in the arid and semi-arid regions occurring in regions as widely separated as the subtropical north (latitude 17°S) to the temperate south (latitude 35°S) (Figure 4). The districts in which beef cattle are produced in northern Australia receive monsoonal and tropical cyclonic rains in summer and there is a mid-to-late summer peak in both quantity and quality of forage followed by a long winter and spring decline in

Figure 5. *Merino sheep for apparel wool constitute the major livestock industry in the southern (winter rainfall) regions of Australia's arid interior.*

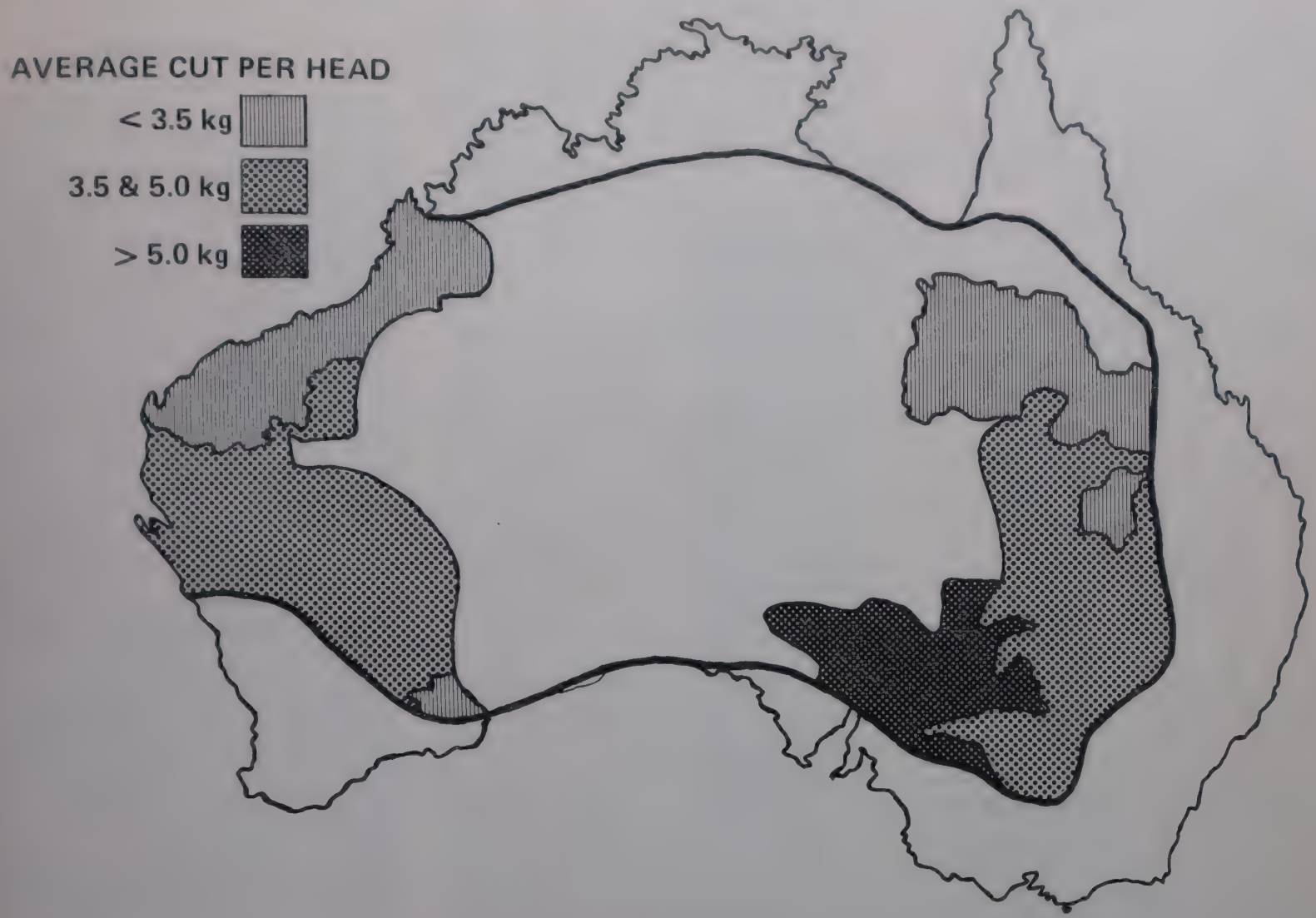
Figure 6. *Beef cattle industry in the northern (summer rainfall) regions.*

both attributes. Further south in Queensland and northern New South Wales at the limits of both northern tropical and southern mid-latitude rains, an occasional winter rain may combine with satisfactory light and thermal conditions to produce pasture outside the summer season. Year-to-year variation is high.

In southern Australia rainfall that is more reliable than in northern regions combines with mild temperature conditions to favour forage production in autumn and winter and maintain the growth of temperate annuals during the colder months of winter.

Beef cattle graze over a wider variety of plant communities in Australia than do sheep. In northern Australia the main beef cattle regions, listed in order of decreasing annual rainfall, include subtropical woodlands and grasslands, brigalow forests, semi-arid woodlands and a variety of arid formations. In southern Australia, in contrast to the situation in the north, there are no regions devoted specifically to beef cattle.

The cattle industry of Australia was based on cattle of British origin. In the 1930s, some Brahman cattle (*Bos indicus*) were introduced into Queensland and, in the 1950s, further importations of Brahman, Santa Gertrudis and Afrikander cattle were made. Brahman cattle represented 8 percent of beef cattle in northern Australia in 1965, but their numbers have increased substantially. More than 25 percent of properties now have some stock, usually bulls, of tropical crossbred derivation. Approximately 30 percent of beef cattle in Queesland have some *B. indicus* ancestry. Brahman cattle have been used to upgrade British breed herds and a number of Brahman-based breeds have been developed including the Droughtmaster, Braford and Brangus and use is also made of the Santa Gertrudis, developed in the USA. Beef production in southern Australia is based on British breed cattle of which Hereford predominates, though Angus and Shorthorn are



SOURCE: BROWN AND WILLIAMS, 1970

Figure 7. *Within the arid zone there are regional differences in sheep productivity. The average greasy fleece weights are lower in the northern tropical and subtropical areas.*

also important. Straight-breeding has been the traditional industry practice although there is an increasing recognition of the advantages of cross-breeding.

The cattle industry in the arid interior and in the north faces considerable handicaps. The low prices offered for cattle, associated with inadequate competition at market outlets, and the leasehold systems of land tenure have discouraged capital investment. Even today few of the Northern Territory properties are fenced, and watering points are widely spaced and inadequate. Returns on capital invested can be as high as 20 percent per annum but climatic variation (Figure 3) is a major factor affecting profitability.

Outlook

About 70 percent of the occupied area of the Australian arid zone is used for pastoral production; but this is decreasing with competition from mining, parks and wildlife reserves and aboriginal reserves. No extension of pastoral occupation seems possible except for minor incursions for short periods into selected areas. It is likely that any gains here would be offset by losses through desertification.

In the arid zone rainfall remains the overriding restriction on production and any attempt to develop these lands along the lines of intensification that may be envisaged for higher rainfall areas is not feasible. Large increases in animal populations in the arid zone could lead to further desertification.

The pastoral industries seem safe from displacement by the cultivation of food crops, owing to unsuitable climate, soil or terrain but sound ecological reasons have been advanced for removing livestock from parts of the arid zone. Unless a conservative stocking policy is adopted, production is likely to decline in the arid zone as desertification accelerates.

Rangeland management has a major

role to play in maintaining forage for grazing stock. Any improvement in animal production in the arid zone must involve studies on ways and means to achieve landscape stability. It has been said that, "There is a challenge for research to develop management standards which maximize for long term ecosystem stability rather than short term animal production" (Slatyer and Perry, 1969).

Squires (1978), in his review of the limits to animal production in Australia's arid zone, lists seven main areas of animal-oriented research that have relevance. Ruminant productivity can be improved by giving research priorities to the following areas: (*a*) range improvement; (*b*) genetic resistance and vector management, especially tick-borne diseases and blow-fly control; (*c*) increased animal unit production through improved conception rate and decreased foetal and perinatal mortality; (*d*) development and evaluation of systems — biological, ecological engineering, economic and social — for resource use, ruminant production and product utilization; (*e*) development of new products such as meat protein concentrates and texturized products from trimmings and edible offals; (*f*) improvement of meat production through genetic selection; and (*g*) supplementary feeding programmes designed to satisfy mineral and other nutrient requirements of lactating and pregnant animals. It must be remembered that some animal production methods are not compatible with long-term resource stability. Resource stability is clearly important and in the long term is the type of research likely to pay off.

Most of the range improvement will come from the application of sound management to existing areas of natural vegetation but some improvement might also arise from rehabilitation of degraded areas through a reseeding programme. Little has been done in the arid zone of Australia yet on the re-establishment of native perennial grasses and the success rate for plants introduced from other countries has been disappointing. Over 1 000 plant introductions have been evaluated at sites within the arid zone but without much success. A notable exception is buffel grass (*Cenchrus ciliaris*) although the area where it will establish without inputs of phosphatic fertilizers is limited.

The author believes that the Australian arid zone can produce more red meat than at present and large quantities of apparel fibres. The cost effectiveness of this action is uncertain, however, in the light of the vastly greater potential for development in the non-arid regions. Mannetje *et al.* (1977) state:

> Australia's beef production is particularly vulnerable and very dependent on world market trends. In the short term there does not appear to be much scope for greatly increased beef production, but given increased world population, increasing buying power and increasing shortages of energy and food grains, the long term outlook is one of greater demand for beef from low energy input production systems on land that has no alternative use for food production.

The situation for fibre production is less clear. The potential exists for vastly increased production of carpet and other speciality wools, of mohair and cashmere, but the current embargo on the import of ruminants prevents the full potential from being realized. Despite a seemingly inevitable doubling of the world's population by the end of the century, the future prospects for wool are clouded by uncertainties as to its competitive position with the fibre products of the petrochemical industry. However, the exponentially increasing depletion of the world's fossil fuels and mineral resources may give the competitive advantage to wool. The energy cost of harvesting the photosynthetic resources of arid Australia is small; the ruminant acts as a self-fuelled, self-propelling, self-servicing and self-reproducing harvesting machine. It is also a good meat and fibre processing factory, which can operate efficiently on a fluctuating feed quality and availability as on a constant feed intake.

While there are advocates of new livestock enterprises based on newly domesticated animals (e.g., the eland), or the cropping of wild animals (e.g., the kangaroo) the prospect of any significant contribution to arid-zone production is not good. Even if this proves to be an overly pessimistic view it is not feasible to import ruminants into Australia under the stringent quarantine procedures currently in force.

Conclusions

Despite the vastness of the arid zone and the large areas that are currently unoccupied there is little scope for large-scale expansion of animal production under the economic constraints that apply now and that are likely to apply in the short term. The cost/price squeeze is, if anything, going to favour development in the more humid areas, especially as higher fuel costs make transport expensive. The arid zone has, in the past, had a considerable comparative advantage and the extensive nature of the operation has made for a high efficiency per man and per dollar invested. Some of this advantage may be lost in the future. Intensification of production is not a viable option without greater safeguards to environmental stability. Research priorities should be aimed toward rangeland management, especially toward the multiple use of these extensive public lands; the socio-economic sciences will play an increasingly important role in this in future. ■

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Recent developments in farm fence construction

A.H. Bishop

Over most of the 10 000 years since sheep and cattle were domesticated, they have been tame and docile, and grazed under supervision of shepherds or yarded or housed. With the expansion of colonial powers in the eighteenth and nineteenth centuries, the development of extensive grazing holdings became common both in North and South America and Australia and New Zealand. Sheep and cattle were grazed on open rangeland and shepherds or cowboys were required to control and protect them.

These developing grazing industries were soon confronted with acute labour shortages and consequently various forms of fencing were developed. Initially fences were made from fallen trees and bushes, but from the middle of the nineteenth century, wrought iron wire became available. Subsequently this was replaced by mild steel wire. Barbed wire was invented in the United States in 1874 and its production increased rapidly in the next decade. It became the wire that fenced the developing "west." Fabricated fencing was also invented in the United States and in due course was manufactured in most countries with extensive grazing industries. In Australia and South America, fences of plain wire and posts and droppers were developed and these became widely adopted in grazing country.

In the 1960s a whole series of technical developments provided a new approach to fence design. These included the preservation of fencing posts and the use of light-gauge high-tensile steel wire, electrified wire and a whole range of droppers, staples, insulators and other fixing devices. In addition, machines and tools were invented for driving and boring posts and for

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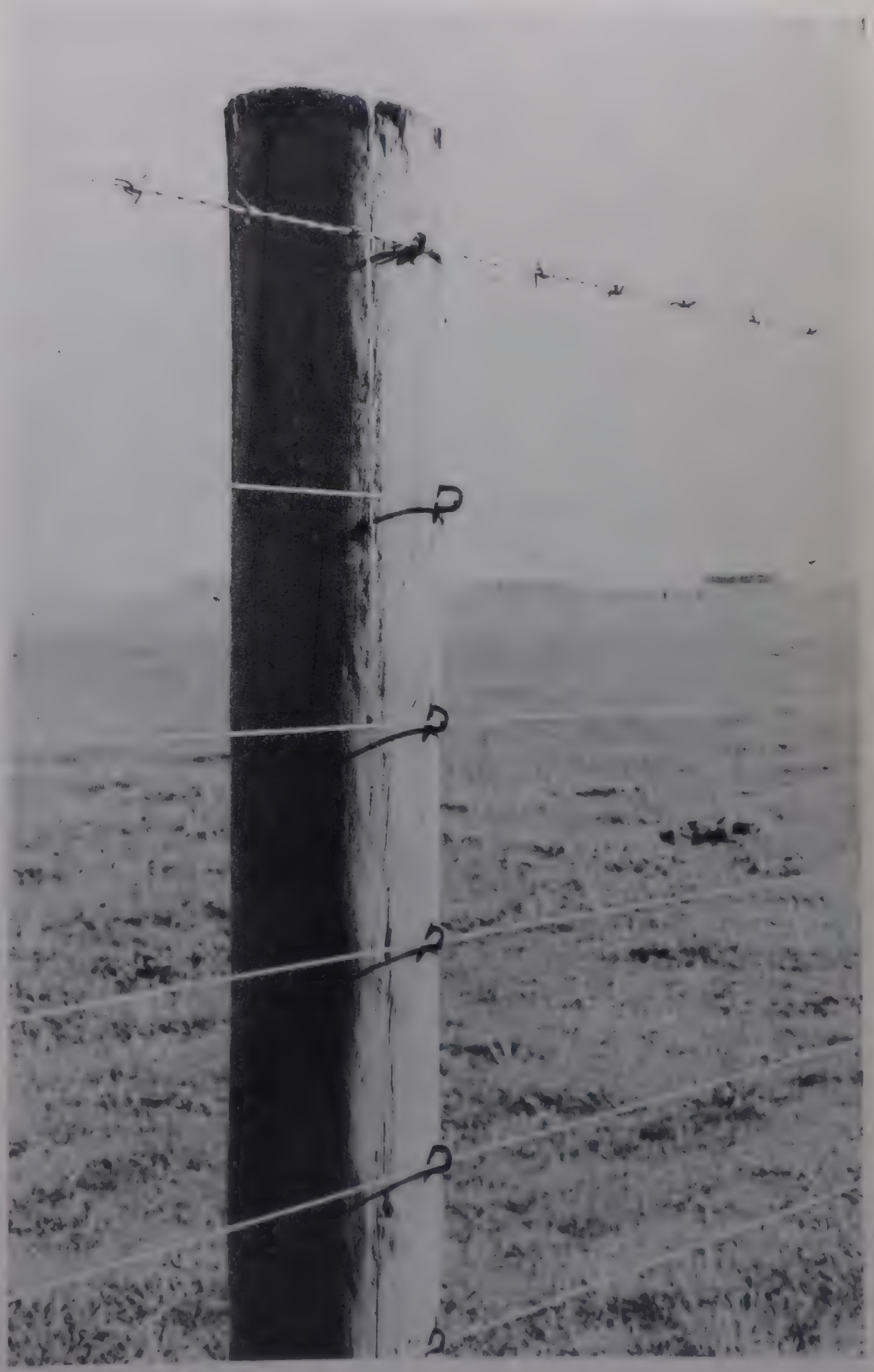


Staples are quite satisfactory for attaching wires to posts

straining and fixing wires. Out of these innovations, several new types of fences emerged: high-tensile plain wire fences, fabricated fences, multi-wire electrified fences and suspension fences.

Factors that affected the choice of fence for a particular environment included:

- The type of stock to be fenced and the intensity of land use;
- The association with other enterprises, especially cropping and the stage of development of the area in terms of pasture improvement and capital investment.

Lightweight posts being driven with a mechanical hammer

Posts for fencing

A major consideration in designing fences is the choice of material for fencing posts. If indigenous or plantation timber is available it is likely to be less expensive than steel. However, different species of native timber vary considerably in durability; and the life expectancy of the timber is of particular importance to the life of a fence.

Timber preservation provides a new approach to fencing posts as it enables light-weight round posts to be used. Suitable preservatives include creosote or other oil-soluble preservatives and water-soluble solutions of arsenic, copper and zinc. Simple methods of preservation include soaking in drums or troughs; for industrial application, the use of a pressure cylinder to handle the large quantities on a commercial scale has been developed. Different procedures are required for softwood and hardwood timbers.

The long life-expectancy of treated timber has been established in experiments conducted in many countries. An average life of 35 years or more has been demonstrated. When treated timber is used, posts can be reduced in size so that they are just strong enough to do the job. These lightweight posts are suitable for driving and they are easy to transport and install. Where a power driver is unavailable or unwarranted, small round posts when given a blunt point can be set with a hand driver if the soil is damp. If timber is unavailable, steel posts can be used. These may range from 1.65 to 1.80 m in length and various cross-sections are available. Holes are stamped into the posts to take wires.

Two distinct strength requirements should be considered to select posts of the minimum size consistent with the use to which they will be put. One is the resistance of the post to breaking and the other its resistance to being pulled or pushed over. The resistance to pulling over depends on soil type, diameter of post, depth of set and whether it is driven or set by ramming in a hole.

Tests have shown that a driven post is one and a half times as firm as a post set by ramming in a hole. It has also been shown that diameter has little effect on the stability of timber posts whereas the depth of set is very important. Increasing the depth by one third will double the resistance to pulling over of a post.

When timber has been treated, small posts can be used; pine posts 100-110 mm in diameter or hardwood posts of 90 mm are satisfactory. Stapling is a satisfactory method of fixing wires to treated timbers and requires less labour than does boring the posts for wiring.

Strainer assemblies for fence ends and corners

Efficient fence ends are as vital to the function and life of a fence as a foundation is to a building.

Technically a fence end can be considered a foundation and design concepts and performance on loading are analogous to those of the foundations of other structures.

Professor Henry Giese of Iowa State College studied fence-end design and his work became a basis for modern methods. He compared designs using a diagonal stay tied back with a cross brace of wire, with a design having a horizontal stay fixed near post-top height and tied back from the top of the brace post to the foot of the strainer post. He concluded that assemblies with the horizontal stay would carry a maximum load 25 percent greater than those with a diagonal stay. By increasing the length of the overall assembly, the total load carried was increased and vertical movement substantially reduced. The designs suggested by Professor Giese have been widely tested in the United States and in Australia. The principles arising from the work and subsequent experience in Australia are as follows:

- The depth of embedment is of particular importance and the force required to overturn a post is proportional to the square of this depth;
- Driven posts are more resistant to overturning than rammed posts;
- The overall length of the assembly is important;
- Designs with a horizontal stay are more stable than those with a diagonal stay;
- For corners, separate assemblies each with its own end post should be used.

In recent years prefabricated steel fence ends have become available; they are widely used in areas where timber is scarce. A design which has had some success consists of a post of 2.1 m made from an 88 × 99 × 6 mm angle-iron, a diagonal stay consisting of a 6 cm tube, 2.2 m long, and a heavy base-plate of flat steel 33 × 25 cm. Two

A pilot hole is sometimes necessary for large posts or in hard ground

steel ground-anchors are driven through sleeves welded on to each face of the angle post just below ground level. The tube-steel stay is attached to the post and to the base plate and the latter is driven into the ground with a sledge-hammer. The function of the ground anchors is to prevent lifting and to provide additional bearing against the soil.

These features contribute to both effective performance and quick assembly and can be installed by one man in about 20 minutes.

End assembly. Long stays give greater strength

The wire component

In most fences, steel wire provides the barrier against stock. The factors that influence a performance of durability and economy in fencing wire are: the quality of the steel, the diameter of the wire and the thickness of a zinc coating. Breaking strain or breaking load is the maximum load a wire can sustain without breaking and this depends on its diameter, the quality of the steel and on the drawing and processing it has received during manufacture. Working loads for a wire refer to tensions to which it is safe and practical to strain wires and these are well below half of the breaking loads of wire.

Working loads for a fence however are working loads that are safe for the wire, safe for the fence ends and functional in producing a stock-proof fence. A final wire tension of 1.3 kN is generally satisfactory for a wire in a fence. However, decay in sapwood in untreated timber posts and the annual cycle from wet in winter to dry in summer can cause end posts gradually to move, especially if they are not deep enough in the ground. Such movement would reduce the tension.

The elasticity of a wire is its quality of being able to lengthen when pulled yet return to its original length when the pull is relaxed. The elongation is proportional to the pull for working loads. For wires of different diameter the elongation produced by a given loading will depend solely on the diameter of the wire. Thus, for the same pull a thinner wire will stretch more than a thicker one and can be said to have a better elongation. This is the same for all types of steel.

Table 1 sets out, for wires commonly used in fencing, the extension to be expected from 1 kN of tension, and conversely, the loss in tension for 25 mm of movement.

It is apparent that, for finer wires, the elongation of a given load is much

TABLE 1. **Elongation and elastic rate for a fence 220 m long**

Wire type (mm)	(gauge)	Extension for 1 kN tension (mm)	Loss in tension for 25 mm movement (N)
4	8	90	320
3.5	9	140	200
3.15	10	150	185
[1] 2.8	11	170	165
[1] 2.5	12	210	135

[1] High tensile.

TABLE 2. **Efficiencies of fencing knots**
(Percentage)

Wire type	4 mm Standard	3.15 mm Standard	2.8 mm [1]	2.5 mm [1]	Iowa Barb	1.6 mm Barb [1]
Figure of 8	80	73	66	65	74	66
Pin and Loop	78	73	60	52	—	—
Donald	76	67	64	53	64	61
Double Loop	69	63	46	46	88	61

[1] High tensile.

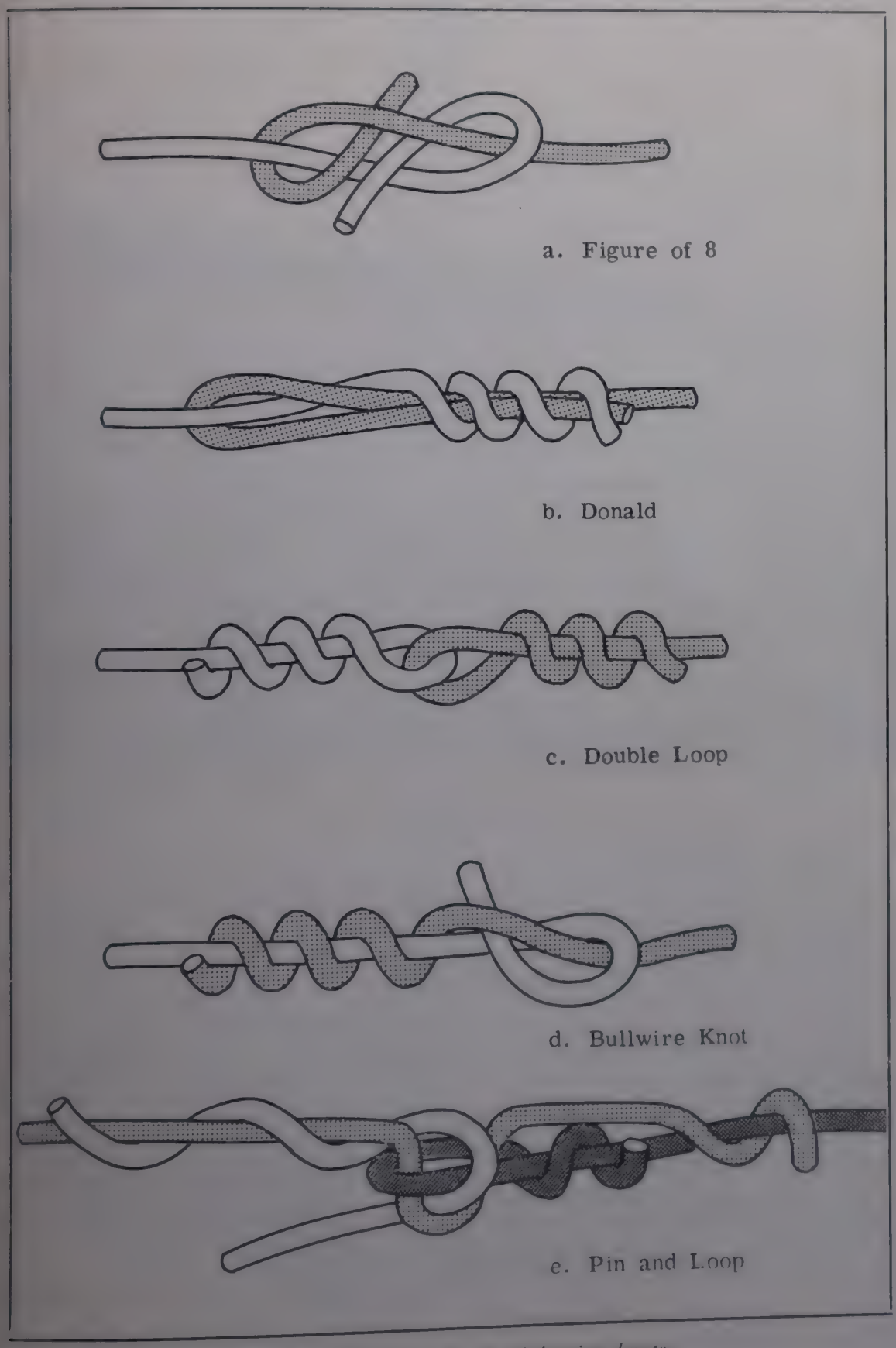


Figure 1. *Different types of fencing knots*

better and the loss in tension for a given movement is less than for thick wires. This leads to much better performance in a fence.

Fencing knots

In practice, fencing wire is always knotted when used in a fence; and the type of knot used and the strength of the resulting join determine the effective strength of the wire. In fact, since the join is the weakest part of the strained wire, the breaking strength of the knot is more important than the breaking strength of the wire.

Four types of knot are shown in Figure 1. Table 2 shows the efficiency of these knots expressed as the mean breaking strain of the knot as a percentage of that of the wire.

It is clear that all knots lower the breaking strain but for plain wire the Figure-of-8 knot was more efficient and more reliable than the others. However, it presents difficulties because after it is tied there is a loss of 30-50 mm of length before the knot takes the strain. This disadvantage limits its suitability for short strains. However, with long strains of high-tensile wire it is possible to pull in the extra length of wire to give a satisfactory tension with a Figure-of-8 knot. With practice, the loss in length after tying this knot can be reduced.

Fence designs

Several new styles of fencing have been developed during the 1960s as a consequence of new materials and new technology. High-tensile steel wire contributes to all of them. The possibilities of fabricated fencing have been extended because of the wider range of designs now available. Significant improvements in electric fence energizers have led to progressively improving designs capable of playing an important part in overall fulfilment of the many demands for fencing in the grazing industry. These new styles of fencing provide the modern alternatives described below.

High-tensile plain wire fences. These fences differ from the original plain wire fences in using more plain wires and less barbed wire, thinner

high-tensile wire strained to a higher tension, more durable, preservative-treated timber posts set wider apart, modern reliable fence ends, and a variety of designs of droppers. The concept is to use wire tension, combined with the better performance of fine wires and modern fence ends, to cut down on post and dropper spacing yet provide impenetrable fences.

Posts are spaced 8 to 10 m apart and eight or nine wires are commonly used in heavily stocked sheep and cattle country. The most common gauge for wire is 2.5 mm but 2.8 mm is sometimes used.

Droppers include bored or slotted treated timber, pressed steel, and a variety of wire droppers. The use of treated and selected timber has enabled the size to be reduced relative to the widely accepted hardwood dropper. Attachments include grooves to take the wire, which is secured by a pre-formed tie, or bored holes for threading the wires through.

Pressed-steel droppers used with pin attachments have sufficient punched holes to adapt to any wire spacing. The pins are bent over with a special tool to fix each wire. A new design has slots to accommodate the wires and a special tool to fit the wire so that it is locked in position. One wire dropper has a quick attachment in the form of a Figure-of-8 loop which attaches to the wire when the dropper is turned. The top and bottom wires are secured to the tails of the dropper after turning to attach all the intermediate wires. These need to be ordered to match the wire spacing but they provide quick attachment and free movement of the wires.

Fabricated fencing. This is a manufactured product in which the required number of wires are woven together with vertical wire pickets attached at appropriate intervals. The whole mesh can be unrolled on the fence site, joined to the preceding rolls and strained to appropriate tension for attaching to the end assemblies and posts. Various types of fences are shown in Figure 2.

Fabricated fencing can be used with post spacing of up to 10 m depending on the slope and smoothness of the land. Barbed wires (one or two are usually used) can be attached to the mesh by means of pre-formed clips and no droppers are required. It is most important that the whole mesh be strained to a satisfactory tension. This can be done by means of a tractor if the mesh can be attached to a satisfactory clamp. Alternatively, manufacturers make specialist equipment for straining the mesh and this gives higher tension and better control than the use of a tractor.

Full-height fabricated fencing, comprising seven- or eight-line mesh, 0.9 m wide, plus one barbed wire, makes a secure fence for sheep and cattle in conditions of fairly intensive grazing. It is competitive with high-tensile plain wire as regards cost and can be erected with less labour.

Suspension fences. In tropical grasslands or semi-arid grazing for cattle, paddocks are very large, stock den-

Droppers reduce the number of posts required

sity is low and the cost of fencing per animal carried becomes a critical factor. In response to this need, low-cost fences with only three or four wires, wide intervals between posts, and very long strains were developed. They are called suspension fences because they are dependent upon a high tension to keep wires at an appropriate height from the ground between posts.

In northern Australia they are frequently made of three barbed wires to which wire spacers are attached. However, under such conditions, cattle or vehicles are likely to run into the fence if bush is present. For this reason the strength and elasticity of the wire are important in providing a fence that will survive such collisions without serious damage. High-tensile steel wire, if strained in long lengths and free to move through post and dropper attachments, can do this much better than barbed wire. Furthermore, it costs half as much as barbed wire so there is a case for using four or five plain wires rather than three barbed wires. Thus it seems best to use high-tensile wire in conjunction with light-weight wire droppers for such suspension fencing.

Slotted droppers can cope with almost any wire spacing

Electric fencing. The use of an electrified wire in fencing introduces a modern technique that adds to the stock-holding capacity of the farm fence. The principle involved is to make the wire repellent to animals, rather than to create a physical barrier. As a structure, an electric fence can be weaker and have wider openings than a conventional fence. The aim is to construct a minimum frame of wires that animals cannot penetrate or climb over without getting an electric shock.

During the late 1960s, the development of modern, powerful, electric-fence energizers that are not seriously affected by the contact of growing plants with electrified wires has led to the development of electric fence designs that farmers can rely on with confidence. Provided they are well built and maintained at a reasonable level of efficiency, they can be a valid alternative to other types of modern fencing.

To provide an effective electric fence, one terminal of the energizer is connected to earth and another to some or all the wires, but these remain insulated from earth either by the posts themselves or by insulators. A circuit is completed when an animal bridges the gap between the energized wire and earth either directly or via an earth return wire connected to the earth terminal of the energizer. The animal receives a shock as the electric pulse flows through it.

Pressure-treated round posts should be considered for electric fences. Under some conditions insulators may be dispensed with if creosote-treated wood posts are used. Post spacings up to 20 m are common and even greater spacings (up to 40 or even 60 m) are sometimes recommended where droppers are used.

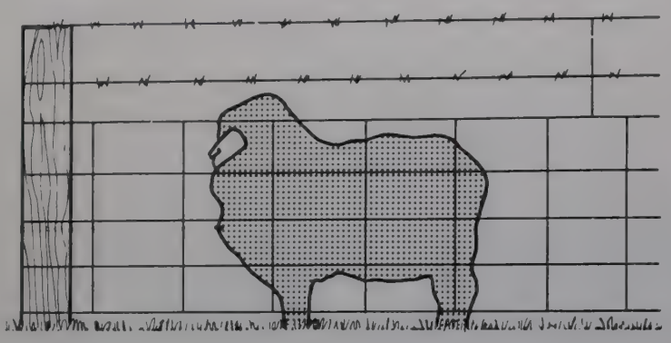
The number of wires required will depend on the type of animals being

contained, the stock density and other factors. Four wires make a useful fence for cattle and of these two would be connected to earth and the other two would be live. This is particularly important where the conditions are dry for much of the year. For sheep and cattle, up to six wires could be used.

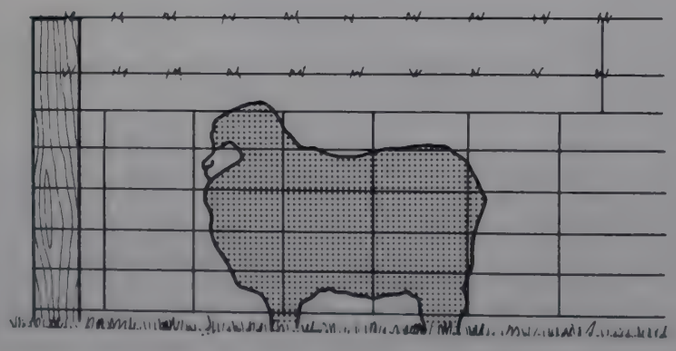
Porcelain insulators, although fairly expensive, are recommended for permanent electric fencing. Many types of plastic insulators are on the market but these have not yet the proven life of good porcelain. Among them black plastic insulators are likely to resist sunlight better than coloured ones.

Good earthing is essential for electric fences to be effective. Earthing materials should be non-corrosive and have a large surface area, and they should be located in moist earth. Galvanized-steel posts and new galvanized piping both make good earthing stakes.

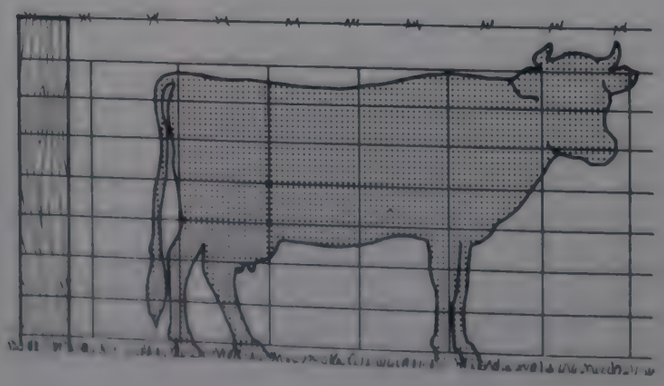
Under dry conditions an earthing steel stake will be needed every 500 m. The energizer *must* be adequately earthed. More systems fail because of inadequate energizer earthing than for any other reason. Depending on soil moisture, three to five 1.8 m galvanized-steel posts should be set 1.5 to 2 m apart and connected together



5 line
67 cm high
30 cm between pickets



6 line
70 cm high
30 cm between pickets



8 line
90 cm high
30 cm between pickets

Figure 2. *Three types of fabricated fence*

and to the energizer. A switchboard located near the energizer can be used to divide the whole fence circuit into a number of subcircuits, which can be checked easily each time the energizer is checked.

Accurate measurement of the peak voltage of a pulse by using a voltmeter is the most satisfactory way to check the electrified circuit. A daily check of the voltage is justified and if the voltage is at the expected level, no further action is required. If the voltage is low, the switching system can be used to isolate successive sections of the fence. When the voltage recovers, the fault will probably be found in the section isolated at that time. Regular maintenance is essential to the success of electric fencing.

Fencing as a means of land development

The use of fencing has developed where the grazing of animals is a major enterprise and land is held under a relatively secure system of tenure in which the occupier has a vested interest in the long-term productivity of the land. In many developing countries, these conditions are being established where they did not exist previously. In such a situation fencing can contribute to the upgrading of land and to the development of new and more efficient farming systems.

Fencing is also a means of integrating the various capital improvements — sheds, yards and water — into a workable framework for managing land and harvesting the production of crops and livestock. It can add to the effectiveness of the whole system if it is efficient, but lead to serious breakdowns if it fails to function as required, or has too high a labour demand. The development of a fencing policy for a property needs to be based on the present status of all improvements on the property, the financial situation, and the aims of property management with respect to enterprise mix and the intensity of production.

The type of stock and the intensity of land use both influence the pressure on a fence. High stocking rates and small paddocks both increase the frequency with which animals are confronted with a fence. Wool-growing sheep are timid in their approach to a fence whereas fat lamb ewes are frequently aggressive in attempting to crawl through or under a fence. Cattle are more inclined to rub on fences and they are probably more intelligent in their attempts to get through.

Fabricated fencing

The major cost of a fence is in the materials used so that the number of wires and post spacing are important and need to be related realistically to expected performance.

The cost of erection is a major consideration in the economics of fencing; it comprises about 30 percent of the total cost for plain wire fencing and about 20 percent when fabricated fencing is used.

Fencing has much to offer developing countries as it can accentuate and enhance social changes involving attitudes to the use of land, and the application of modern techniques to livestock and cropping enterprises. ■

Field collection of animal disease data in developing countries

D.W. Broadbent

Much attention has been paid in recent years to the computation and utilization of animal disease data. Sophisticated systems of data processing have been installed in many countries to provide a data base for decisions on disease control policies. However, most of these data processing systems have been designed either to utilize existing systems of data collection or with a blithe disregard of the available sources of data. Most existing systems of data collection are based on disease notifications and the work of veterinary diagnostic laboratories, whose principal function is the investigation and solution of animal health problems at the individual farm level. If it is accepted that the primary objective of disease-data processing systems is the provision of extensive, valid, quantified information on health problems, then an appropriately designed system for collecting data from the general farm animal population is an essential prerequisite. This article is based on a project in northwest Argentina whose primary objective is the construction of a disease-data collection system specifically designed to feed a complementary data analysis system in order to quantify animal health problems in the region.

The project, with headquarters in Salta, covers the five provinces of northwest Argentina. It is based on a regional veterinary diagnostic laboratory providing support to the project's field veterinary staff and to private veterinarians working in the region. The project also offers a field investigation service to both livestock producers and their private veterinary advisers.

The primary objective was to identify and quantify the disease problems existing in the various animal populations of the region. It was decided to do this by analysis of data generated by systematic surveys and supplemented by investigation of individual farm or area disease-problems. At the same time it was necessary to determine the relative importance of the various disease entities in terms of their impact on production. To establish some management and production base-lines, a questionnaire covering the physical characteristics of the establishment, its management and its production was completed for each farm at the time of testing the animals. The first survey completed has covered the entirety of the five milk sheds of the region and has provided detailed information on their health status and, as far as possible, their production (Habich *et al.*, 1977; 1978). Sera have been banked in cold storage and will be subjected to further examination as improvement of the laboratories' technology permits. All the collected data will be processed through the experiment station's computer later in the year. The surveys are now being expanded in scope and will soon be extended to beef cattle populations.

Initial analysis of results has already revealed high incidences, in some areas, of brucellosis, tuberculosis and trichomoniasis. The existence of vibriosis has been established for the first time in the region while very low serum levels of copper and phosphorus have been detected. Some parameters of the cattle tick population have been measured and the distribution of blood parasites (*Babesia* and *Anaplasma*) has been mapped. The production parameters collected have included carrying-capacity, reproductive performance and milk production. Details of herd structure, animal replacement policy and management techniques, including disease prophylaxis, have also been collected. All this information was collected in semi-coded form ready for translation for computer storage and processing.

Smaller surveys of goat populations have been performed in response to requests from public health authorities concerned with human brucellosis. These surveys have established high incidences of caprine brucellosis and the pressure of a number of other health problems in these goat populations (Condron *et al.*, 1978).

All this information has been collected in the space of 16 months by a team of 11 veterinarians and biochemists. It has required only two visits to each establishment and has provided sufficient data so that, after completion of laboratory examinations and computation of results, an accurate charac-

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terization of disease status related to an estimate of production will be available for all the dairy sheds of the northwest for the first time.

Resources. The establishment of a collection system is expensive and it is often difficult to persuade authorities to provide sufficient funds. It is important to stress here that unless the system can count on at least a minimum effective resource it should not be started. The minimum requirements include a force of trained field veterinarians equipped to cover all the territory, a laboratory capable of applying appropriate tests quickly and accurately to the large volume of material involved, and trained staff with the time and facilities to handle the mass of data produced. Deficiency in any one of these three areas will not only seriously reduce the efficiency of the system but may also produce erroneous and misleading results.

The allocation of resources differs from that conventionally applied to "Regional Veterinary Diagnostic Laboratories." The increased emphasis on field activities requires an increased expenditure on field testing equipment and large stocks of common glassware such as serum bottles and sample containers. At the same time the relatively diminished demand for some of the more sophisticated examinations such as are employed in histopathology and virology permits a reduction in the expenditure on these sections.

HUMAN RESOURCES. It is essential to provide an adequate number of suitably trained veterinarians, though this is often difficult, especially in developing countries. Besides the laboratory staff who must be competent not only in their laboratory specialty but also in field investigation, a team of field veterinarians trained in epizootiology and preventive veterinary medicine is indispensable.

Although "preventive veterinary medicine" has been much in vogue in recent years, many pre- and post-grad-

Taking a blood sample and applying TB test to a dairy cow in Catamarca

uate veterinary courses still teach primarily clinical diagnosis and treatment of disease in the individual or the herd and provide very little training in "population medicine." Nor do they provide training in practical work, especially in its organizational aspects in the field. As a result, few veterinarians graduate with skills, attitudes or interest in the positive, preventive approach to disease in large populations. Moreover, the financial rewards and the social and professional status of veterinarians in most countries are much higher in either private veterinary practice or academic research.

The concept of a diagnostic laboratory existing primarily to provide back-up diagnostic facilities to a team of field veterinarians is one that is often not readily accepted in many developing countries, where it is considered that the work of a field veterinarian is dull, dirty and degrading whereas laboratory work permits admission to the "white-coat brigade." Nevertheless, it is essential that the whole of the staff function as a team with all members able and willing to work in the field, accepting that the veterinarian in the field plays a key role. Thus the first phase in the development of a data-collection system is frequently the provision of postgraduate training in both theoretical and practical epizootiology to provide veterinarians able and willing to design and execute field investigation and survey work.

LABORATORY SUPPORT. The laboratory support required differs from the conventional veterinary diagnostic laboratory in that emphasis is shifted from a large range of techniques through each of which small numbers of samples are processed, to a smaller range of techniques, each capable of handling large numbers of samples. The relative importance of the different laboratory sections is also altered. Serology and biochemistry take on a greater significance while that of pa-

Taking blood samples from goats, Province of Salta

thology and histopathology diminishes.

The laboratory testing techniques chosen must be applicable to large-scale testing and, where necessary, adapted to the exigencies of the field-sample collection system. The input of samples for testing in a conventional diagnostic laboratory does not generally show great fluctuations with time but the supporting laboratory for a field-data collection system may be obliged to accept 5 000 sera in one month and 500 in the next. It is therefore important to make provision for large quantities of glassware, washing and sterilizing facilities, incubator and cold storage space.

The design and management of the laboratory must be adapted to an efficient flow of material and data to achieve a high throughput capacity. This does not necessarily imply the installation of expensive automated equipment but rather that samples be accommodated in a batch system and that such tasks as labelling tubes be minimized. It is important to standardize equipment as much as possible to facilitate, for example, identification of samples by their placement in a rack rather than by a label. This requires that all racks used for a particular type of sample contain the same number of spaces in the same conformation, eliminating the need for the labelling of individual containers and more than one list of sample numbers. Appropriately designed forms for use in the laboratory minimize time spent recording results and permit the passage of laboratory information direct to the computer and its blending there with the relevant data recorded in the field.

Not all laboratory techniques are amenable to batch treatment. Sowing of bacteriological culture plates must generally be done individually but if micro-aerobic incubation is required it can be achieved efficiently in batches in culture vessels made from ordinary galvanized milk cans rather than expensive glass jars or incubators.

To achieve the throughput capacity necessary an unusually large provision must be made for central services to provide a rapid turn-round of clean and sterile materials. Similarly, the need to maintain large numbers of serum samples requires provision for a large volume of cold storage space.

PHYSICAL RESOURCES. In order to be effective, animal disease data collection systems must be able to provide information on the animal populations throughout the area they intend to serve. In many developing countries important animal populations are maintained in areas to which access is difficult because of poor communications, rough terrain, extreme climatic conditions or remoteness from the operating centre. It is common in such areas to find that means of physical animal restraint such as yards, races and crushes do not exist and that services such as electricity and a clean water supply are also unavailable. It becomes imperative under such conditions for the field team to be completely self-sufficient in the field. Not only do they need vehicles capable of traversing bad roads under all conditions but also ropes, lasso, nose grips, water, disinfectants, etc. They must also carry portable laboratory equipment such as centrifuges, incubators and freezers. This does not imply expensive and sophisticated "mobile laboratories" but that some equipment, rugged enough for field use, be purchased along with the more delicate laboratory equipment.

Data collection. In such difficult areas severe frequency limits are imposed on surveys, so that it is possible to visit herds only once or twice a year; methods must be adapted to this restriction. Field work associated with such surveys is very expensive and so each visit must be used to gather a maximum of information. With two visits in 72 hours, it is practicable to apply a skin test for tuberculosis, and to take samples of blood, faeces and external parasites. At the same time, the pregnancy status of females can be established, preputial and vaginal samples taken, and a sample of the animals weighed.

In areas where visits to farms must be infrequent it becomes even more important to collect health and production data simultaneously with the collection of samples. This has been done in this project by filling in questionnaires on production separately from those on health, but at the same visit. It is important that these questionnaires are filled in by the visiting veterinarian and that he be trained to use properly a well-designed form. If not, the sampling usually receives an unacceptable bias. In particular, farmers unaccustomed to being questioned about their herd will either provide answers they believe the interviewer will prefer, or those that hide defects in their production system.

Taking blood samples from goats in a remote area of the Province of Salta

In many cases inaccurate diagnosis has produced a distorted picture of the real situation and it is therefore vital to establish accurate, standardized, reproducible diagnostic methods. For example, in many Latin American countries published incidences of bovine brucellosis have been based on unstandardized rapid plate tests (Huddleson), in which the criteria for positive and negative results vary widely. Similarly, the diagnosis of "tristeza," a common name for the babesiosis/anaplasmosis complex, may well have included a range of conditions from leptospirosis to bacillary haemoglobinuria. Production parameters are not generally measured and even such simple data as calving percentages are often not accurately known. Thus many problems such as poor fertility and micronutrient deficiencies may go unnoticed, not only by the farmer, but by his veterinarian as well. Under these conditions it is imperative to measure health and production parameters simultaneously in the apparently normal population.

The design of such surveys intended to characterize the sanitary situation in a region is especially difficult when the basic description of the population is not known. Selection of a statistically valid sample is often not possible in the first instance. The sample may have to be selected on an operative basis, examining all those farms where such work is feasible. Though such a sample is obviously biased, if it is sufficiently large its size may generally be expected to reduce the error to acceptable limits.

Although it is desirable to do a preliminary survey to establish missing base-data before designing and executing a large, detailed survey, the cost of such a survey in developing countries is usually prohibitive. It is therefore frequently necessary to begin to survey a population without knowing what size and structure it has and with only a hazy idea of its geographical distribution. The actual survey and the data processing must therefore be designed with great care to ensure that it is flexible enough to cope with a great range of possibilities. As field work is costly it is essential to make it as efficient as possible by gathering all possible *useful* information in a usable form.

Such "one-hit" surveys can effectively measure the incidences, and partially measure the impact, of many conditions in an animal population. Indeed, for some conditions such as micronutrient deficiency states and subclinical infections, surveys are the only effective means of establishing the incidence in a complete population. However, they provide little information on epizootiological relationships, which must be studied through regular visits to selected farms at shorter intervals. Neither can such surveys provide much information on the incidence or importance of acute, fatal conditions such as rabies or clostridial infections. This information can only be gathered through compulsory notification of confirmed outbreaks of these diseases or through analysis of the records of a field disease-investigation service operated by a veterinary diagnosis laboratory. In most developing countries a system of disease notification is ineffective because of the shortage of veterinarians in the field and the uncertainties of clinical diagnosis. Analysis of the findings of a field disease-investigation service remains the only practical method in developing countries.

The incidence of many disease conditions can be measured during surveys using established diagnostic methods: skin tests for tuberculosis, serologic tests for brucellosis, culture of preputial washings for trichomoniasis, etc. However, some conditions cannot be so readily measured either because suitable methods have not been well established (as in the case of helminth parasites) or because the condition is an acute fatal one. These difficulties can be overcome by:

- Adaptation of known sampling methods, e.g., methods of counting *Boophilus* on animals can be modified to serve for *Amblyomma* spp.;
- Development of new sampling methods, e.g., *Babesia* brain smears from abattoir samples;
- Inclusion in the data pool of information derived from investigation of outbreaks of diseases at the farm or area level.

Data storage and analysis. For any animal health control system to function adequately, its decision makers must have a continuous, valid assessment of the current disease status of the population. Such an assessment can only be derived by analysis of data flowing from the field. The data storage and analysis system must be designed to provide the required analyses but it cannot be designed apart from the data-collection system that will feed it. In developing countries conditions are frequently such that the collection system must be very flexible and capable of adaptation to unforeseen situations. It is absolutely essential that the storage and analysis system be completely compatible with, and as flexible as, the field collection system. This requires that both systems be designed together as individual parts of a whole. ■

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Situation and outlook for animal feeds [1]

□ CEREALS

Production of wheat, coarse grains and rice were all higher in 1978 than in any previous year (see graph). The FAO forecast of total world cereal production in 1978/79 is slightly over 1 400 million tons, some 5 percent above 1977. Of this total, over 50 percent is coarse grains (see Table 1), and nearly 30 percent is wheat.

World grain imports for 1978/79 are forecast by FAO to be of the order of 146 million tons, 4 percent below last season. Of this volume about 77 million tons are expected to be coarse grains and 69 million tons wheat.

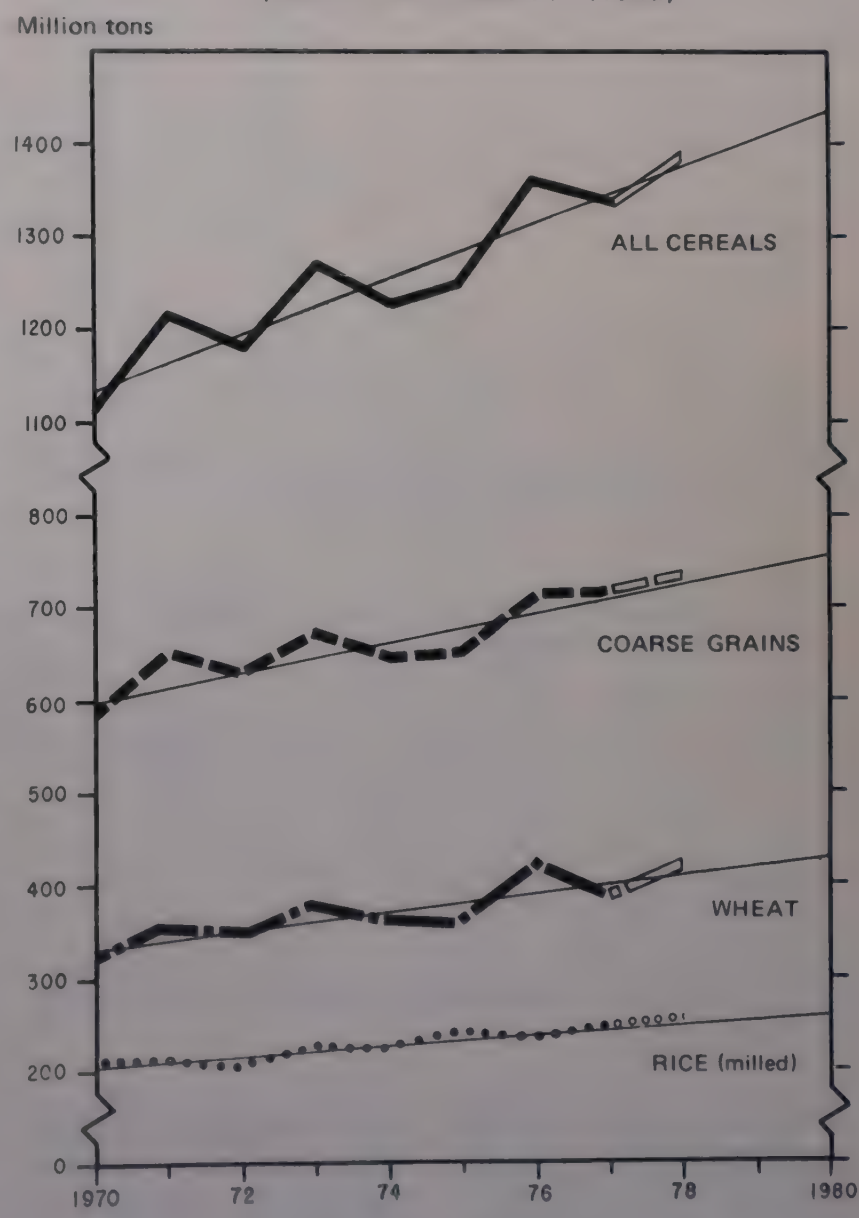
□ CONSUMPTION OF GRAINS AS ANIMAL FEED

About 39 percent of all cereals produced were used as animal feed in the period 1972-74. The proportion was over 60 percent in developed countries (including the USSR and Eastern Europe), and nearly 13 percent in developing countries including China (Table 3). These proportions did not change substantially in recent years.

TABLE 1. **World coarse grain production**

Grain	1976	1977 preliminary	1978 forecast	Percentage of 1978 total
		Million tons		
Maize	333.1	349.4	358.8	48.9
Barley	184.4	172.8	187.4	25.5
Sorghum	52.6	57.6	55.7	7.6
Millet	44.5	42.7	45.1	6.2
Oats	49.6	52.2	51.4	7.0
Rye	29.5	23.7	26.1	3.6
Others	8.6	8.8	8.9	1.2
Total	702.3	707.2	733.4	100

WORLD CEREAL PRODUCTION
(Actual and 1960-77 Trend)



Source: Food Outlook No. 10, 24 October 1978.

Japan accounts for nearly a quarter of the international demand for *coarse grains* (Table 2). While the European Economic Community (EEC) is a large importer of maize and sorghum, it is also an increasingly important exporter of barley and soft wheat.

In the 1978/79 season the consumption of coarse grains is expected to rise, particularly consumption as feed. This feed usage will be affected by a number of factors. In the United States, the strong demand for animal products, the continuation of favourable livestock/feed price-ratios, and higher profitability of feeding maize and sorghum, compared with wheat, are expected to raise the feed use of coarse grains from 117 to 125 million tons. The downswing of the cattle cycle has resulted in lower beef supplies, rising prices for all types of meat, and has made it more profitable to place an increasing number of cattle in feed lots. Utilization is also expected to increase in the major importing countries. In the USSR the big crop and the large livestock develop-

[1] As of November 1978. **Source:** FAO Commodities and Trade Division.

TABLE 2. **Imports of coarse grains, crop years July/June**
(Million tons)

Region	1976/77	1977/78 preliminary	1978/79 forecast
Far East	20.7	24.0	25.6
China	(—)	(0.2)	(2.0)
India	(—)	(—)	(—)
Japan	(15.9)	(17.0)	(17.5)
Near East	3.0	3.5	3.5
Egypt	(0.5)	(0.7)	(0.7)
Africa	1.0	1.5	1.4
Latin America	3.6	4.4	5.8
Brazil	(0.1)	(0.1)	(2.0)
Mexico	(1.1)	(2.1)	(1.8)
North America	0.9	0.8	0.9
Western Europe	35.0	25.4	23.0
EEC [1]	(26.6)	(16.0)	(14.0)
Eastern Europe	8.0	8.0	8.0
USSR	5.5	12.0	8.0
Oceania	—	—	
Unspecified	1.0	1.3	(1.0)
WORLD	78.7	80.9	77.2

Source: FAO.
Note: Since preliminary figures of total imports are generally below total exports, the difference is accounted for under "unspecified" imports. A national allowance for unspecified imports is made for the forecast year.
[1] Excluding trade between EEC member countries.

TABLE 3. **Estimated cereal feed use as a proportion of total cereal consumption**
(Average 1972/74)

Region	Total cereal consumption	Animal feed use	Animal feed use as percent of total
	. . . *Million tons* . . .		
World total	1 226	483	39.4
Developed countries	668	412	61.7
Developing countries	558	71	12.7

Source: FAO.

ment programme should lead to increased volumes of coarse grains fed to animals. Feed use of maize and sorghum is expected to continue to rise in Japan due to an accelerated increase in meat consumption but the rise could be slowed by government decisions to use surplus rice as animal feed. In the EEC livestock numbers are rising, but coarse grain utilization is not expected to expand in view of the increasing availability of domestically produced wheat with low baking quality from high-yielding varieties, the abundant availability of roughages, and further inroads of non-grain feed ingredients such as cassava, citrus pulp, maize gluten and grain milling by-products into compound feed rations. Developing countries as a whole used an estimated 80 million tons of grains for animal feed in 1977/78. Feed grain consumption should continue to increase particularly rapidly in a number of developing countries, with rapid income growth resulting from rising foreign exchange earnings (i.e., in Iran, the Republic of Korea, Malaysia, Mexico, Nigeria and Venezuela).

In developed countries a considerable increase is expected in the utilization of wheat for animal feed. Larger quantities of wheat are likely to be fed in Western Europe and the USSR following greater availabilities of it. In Eastern Europe, a greater volume of feed wheat will become available as a result of the larger proportion of low-quality grains harvested in that region this year. In the United States, however, wheat feeding should be about 3 million tons, 2 million tons down from the high level of over 5 million tons in the last season as the sharp decline in maize and other coarse grain prices has made the feeding of wheat less attractive.

☐ OTHER HIGH ENERGY FEED

One of the consequences of the EEC's Common Agricultural Policy (CAP) has been that, in many parts of the EEC, feed grains have become more expensive than locally produced agricultural by-products, and than a number of imported energy concentrates with low import duties and levies. These energy concentrates, which are often described as "cereal substitutes," include:

— Cassava or manioc pellets
— Milling by-products (cereal brans)
— Starch by-products, such as cereal gluten meals
— Sugar residues, including sugar beet pulp
— Brewing by-products
— Fruit residues, such as citrus pulp pellets
— Copra meal

While countries generally welcome the greater utilization of locally produced cereal energy substitutes for animal feed, their rapidly increasing imports into the EEC (Table 4) has led to pressure from large sections of the Community's feed grain producers to limit trade. This trade accounted for an estimated 10 million tons of barley energy equivalent in 1978, of which over half was cassava, and a quarter milling and starch by-products. Due to voluntary cassava production and export restrictions in Thailand, which accounts for over 85 percent of the global cassava exports, no significant increase

TABLE 4. **EEC imports of feed substitutes**
(Thousand tons)

Commodity	1974	1975	1976	1977 preliminary
Cassava (manioc)	2 250	2 337	3 039	3 792
By-products of milling industry/ wheat bran	1 209	1 504	2 256	1 880
Corn gluten based flour	694	930	1 147	1 480
By-products of sugar industry (beet and cane)	138	187	394	280
By-products of brewery industry	64	57	95	—
Fruit wastes and citrus pellets	340	490	665	950
Other vegetable products	21	56	136	—
Total	4 716	5 561	7 732	8 500

Source: COCERAL (EEC Committee for Trade in Cereals and Animal Feed). Primary sources were: Ernährungsdienst dated 27 August, and working document of the EEC Grain Consultative Committee (26 May 1978 meeting).

in the trade of cassava pellets is expected in 1979, though the growth in the utilization of other by-products and residues is likely to continue.

□ OILSEEDS, OILS AND OILMEALS

Preliminary estimates indicate that the 1978 output of *protein from the main oilseeds and fishmeal* reached the record level of 36.3 million tons, 14 percent above the reduced output of 1977, and 2.1 million tons higher than the long-term trend.

Soybean meal protein was expected to provide by far the largest increase in both output and exports, although output of cottonseed, sunflower, rapeseed and linseed meals has also shown significant gains.

A preliminary forecast of production for the crops to be harvested in late 1978 in the northern hemisphere, and in early 1979 in the southern hemisphere, suggests that world output will be above the record levels of 1977/78 (Table 5). However, prospects could change as the season progresses.

By far the biggest increases in oils and protein meal output are expected to come from increases in soybean production. The United States crop of late 1978, based on crop conditions as of 1 October, was forecast to reach a record of 48.8 million tons of soybeans, 0.9 million tons higher than the previous crop. The Brazilian crop of 1978 was forecast to recover to a record of 13.0 million tons, more than one third higher than the drought-reduced crop in the preceding year.

Output of groundnuts is expected to show some recovery, mainly as a result of a better crop in Senegal. Sunflower seed output is likely to increase moderately, with only a slight increase likely in the USSR crop, but another sizeable gain in the United States crop. Increased rapeseed production is forecast, reflecting a 90 percent increase in Canadian planted area. In contrast, a decline is forecast in cottonseed output, mostly because of smaller production in the United States.

Beginning stocks of oilseeds, oils and oilmeals in a number of major exporting and importing countries are likely to be somewhat higher in 1979, hence total supplies of oils and protein meals should be ample. However, if the strength of demand shown in recent years continues through 1979, the level of existing stocks would not provide a very large reserve against unforeseen crop shortfalls in major producing countries.

Selected market indicators with comparisons

Price index numbers	October 1978	October 1977	Change from year ago
US feed grain index	177	167	+ 10
FAO oilcake and meal index	220	199	+ 21

Sources: Feed Market News, California Department of Agriculture, and FAO Commodities and Trade Division.

□ PRICE SUMMARY

Coarse grain prices in international markets continued their downward movement, in terms of US dollars, during the early months of the 1978/79 season, a trend that commenced in June 1978 when prospects for another large crop in the United States weakened prices. This development was accompanied by a widening price spread between wheat and maize during the first quarter of 1978/79 (Table 6). Coarse grain prices started to move up again in October 1978 following the increase in stocks placed under the farmer-owned reserve programme in the United States. It is likely that this programme, together with the recent announcement of a combined set-aside and paid diversion programme for 1979,[1] would continue to lend support to prices and prevent them from declining to the former low levels despite expected heavy supplies and rising stocks.

International *wheat* prices during the early months of the 1978 season strengthened soon after the harvest period in the northern hemisphere. The strengthening of market prices in spite of the good crops expected in the USSR, Western Europe and China, and the anticipated higher level of world stock, is pri-

TABLE 5. **World production of oilmeal protein — estimates and trends**

(Million tons of protein equivalent)

Meal	1977	1978 estimate	1979 forecast
Soybean	18.7	22.8	24.8
Cottonseed	3.5	4.0	3.7
Groundnut	2.2	2.2	2.3
Sunflower	1.5	1.9	2.0
Rapeseed	1.2	1.5	1.8
Linseed	0.4	0.6	0.6
Other vegetable	0.9	0.9	0.9
Fish	2.9	2.9	3.0
TOTAL	31.4	36.8	39.2
Long-term trend values (1967-77)	33.1	34.2	35.2

TABLE 6. **Export prices of grains and soybeans**

($US/ton f.o.b. US Gulf)

Date			Wheat (US No. 2 Hard Winter ord. prot.)	Maize (US No. 2 Yellow)	Sorghum (US No. 2	Soybeans (US No. 2) Yellow)
1977/78	July/June		116	96	89	236
1977	November		115	93	90	220
1978	June		129	107	97	263
	July		130	97	91	251
	August		130	92	88	246
	September		134	91	87	250
	October		140	96	94	256
	November	2	141	101	97	262
		9	140	100	95	247
		16	140	98	95	243

Sources: Wheat — International Wheat Council; Maize, sorghum and soybeans — USDA.

[1] The United States coarse grain programme for 1979 includes a 10 percent set-aside and an additional 10 percent paid diversion for both maize and sorghum as well as a 20 percent set-aside for barley.

marily due to a series of policy measures taken by the United States Government to stabilize wheat prices. As a result, international wheat prices are expected to remain stable during the 1978/79 season unless aggressive marketing policies are adopted by exporting countries to minimize stocks.

International prices of most *oilseeds and oilmeals* — in US dollar terms — have fluctuated within small ranges since June 1978. Influences resulting from such fundamental factors as revisions of crop forecasts and estimated import demand, as well as from technical factors (such as currency changes), have by and large tended to offset each other. ■

IV World Conference on Animal Production

The IV World Conference on Animal Production was held in Buenos Aires, Argentina, from 20 to 26 August 1978. It was attended by more than 800 persons from 57 countries.

In preparing for the Conference, the organizers had recognized the concern of many that, despite substantial worldwide research efforts, little progress was being made toward meeting the growing need for livestock products. It was therefore decided that the objectives of the Conference should be to analyse the factors that condition the generation and application of scientific knowledge and to discuss the impact and relevance of recent findings on the efficiency of animal production systems.

Four days of the Conference were devoted to the presentation and discussion of invited papers on bio-economic systems in Latin America, the effectiveness of animal production systems, and recent advances in research. A further day was devoted to a symposium on animal health planning and monitoring, but this was simultaneous with the presentation of over 130 short papers submitted to the Conference.

The description of animal production in different ecological zones of the South American subcontinent gave some indication of the enormous potential of the region. At the same time, it made clear that present levels of output are disappointingly low despite the importance of livestock products in the local economy. The principal reasons for this appear to be poor management on the farm, associated with a lack of economic incentive.

In discussing the effectiveness of animal production systems — the basic theme of the Conference — a wide-ranging series of papers was presented. In each, some mention was made of a systems approach, but it was difficult to see how some of the papers, as presented, fitted into any system. What is meant by the effectiveness of production systems was never defined. If it refers to the degree of adoption of a given system by farmers, then the biologically optimum system may be far from effective, and considerations other than purely economic ones may be involved. It would seem that the effective system is one that meets a predetermined objective; and the worthiness of that objective is of over-riding importance in development. As one speaker pointed out, if the major objective is to alleviate hunger this cannot be achieved simply by producing more food.

The invited papers on recent advances in research provided useful reviews of the nutrition of farm animals and of environment as a factor in reproduction. In addition, there were interesting reports on animal-breeding studies in tropical Australia and on the utilization of pastures in Israel. Both reports are worthy of study in relation to possible wider application of the techniques involved.

In the symposium on animal health planning and monitoring, the principal papers covered the development and implementation of major national disease control programmes in the USA, a herd health programme in the UK, some aspects of the needs and priorities in preventive medicine in Canada, and a socio-economic evaluation of a major disease control programme in Brazil. In the discussion that followed it became clear that the infrastructure for the collection of disease data in most developing countries is totally inadequate. The need to establish field intelligence, simultaneously with a computer-based information system, was generally accepted.

It was unfortunate that the animal health symposium coincided with the simultaneous sessions for presenting papers. This led, once again, to the segregation of animal health and other specialists, all of whom are involved in animal production and need to know far more about each other's problems. This and the sheer impossibility of doing justice to the many short papers were the weak parts of an otherwise very well organized Conference.

Before the meeting closed, it was announced that the V World Conference on Animal Production will be held in Tokyo, Japan, in 1982.

XX International Dairy Congress

International dairy congresses are held under the auspices of the International Dairy Federation (IDF). They are organized every four years by the National Dairy Committee of one of the Federation's member countries. The Federation also holds an annual session attended by representatives from member countries and observers from international organizations concerned with dairying, including FAO, UNICEF and WHO. The XX Congress, held in Paris from 25 to 30 June 1978, was preceded by the annual session.

IDF publishes documents related to the dairy industry covering a wide range of issues from milk production to the processing and marketing of milk and milk products. IDF also elaborates standards concerning the composition of milk and milk products, analytical methods and sampling, dairy engineering, evaluation of detergents, pesticide residues, etc. The work of the Federation is carried out in eight Commissions, dealing with the production of milk, technology, economics, legislation, microbiology, chemistry, science, and studies. The last of these, the Commission of Studies, acts as a coordinating body for the others, which are like working groups.

The proceedings of congresses are grouped accordingly. Papers are offered and discussed during simultaneous sessions of the committees. The emphasis of the XX International Dairy Congress in Paris was on:

- the dairy industry in developing countries;
- human nutrition;
- transfer of know-how;
- quality of milk and milk products.

The Congress was attended by approximately 2 500 participants.

Seventh international course on dairy cattle husbandry

The seventh course in the series of international courses on dairy cattle husbandry organized by the Dutch International Agricultural Centre will be held in the Netherlands from 13 March to 15 June 1979. Participants should have an agricultural or veterinary education up to at least a B.Sc. level, as well as three years' experience in

dairy cattle husbandry or a closely related subject. The course will be conducted in English.

Further information may be obtained from the Director of the International Agricultural Centre, P.O. Box 88, 6700 AB Wageningen, the Netherlands.

FAO/UNDP Expert Consultation on the Economics of Trypanosomiasis

This Consultation was held from 5 to 9 December 1977 at FAO Headquarters in Rome and was attended by nine experts from five countries (France, Kenya, Nigeria, UK and USA). There were also ten observers, including representatives of the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Centre for Africa (ILCA).

Prior to the Consultation, FAO staff members and consultants undertook studies of available data on the economics of trypanosomiasis in four African countries. Reports on these, and further country studies undertaken on behalf of other bodies, were considered by the Consultation. The direct and indirect economic losses caused by animal trypanosomiasis, the costs of control methods and the few cost-benefit analyses carried out so far were discussed. From these it became clear that the data base for economic analysis is deficient. Data on benefits are particularly scanty, mainly because most benefits from trypanosomiasis control are derived through the traditional systems of land utilization in Africa and are difficult to quantify.

At present, eradication of tsetse flies is necessary before disease eradication becomes possible. This in turn can only be achieved in certain circumstances, although elsewhere control of either the vector or the disease (by chemotherapy, chemoprophylaxis or the utilization of trypanotolerant livestock) may be possible. The Consultation recognized that the tsetse and trypanosomiasis problem must be seen as a problem of land use. It emphasized that in order to maximize the economic benefit from any anti-tsetse operation, the control/eradication programme should be preceded by a preparatory phase that includes the training of staff, land resource surveys and land-use planning.

A detailed report of the Consultation was published in English and French during 1978.

XXI World Veterinary Congress

The Organizing Committee of the XXI World Veterinary Congress has extended an invitation to veterinary specialists in all continents and representatives of international organizations concerned to attend the congress which will be held in Moscow from 1 to 7 July 1979. The opening ceremony, plenary sessions, the formal reception and the closing of the congress will all take place in the Kremlin Palace of Congresses situated in the western part of the Kremlin.

The objectives of the congress are to present the state and prospects of development of veterinary science in the USSR; to discuss recent scientific and technological advances and the role of the veterinary profession in providing mankind with valuable animal products; to present problems of tropical veterinary medicine; to discuss present and future problems of veterinary public health as well as the reorientation of veterinary services to animal production on a mass scale; and animal health and related problems of environmental health.

All specializations of veterinary medicine will be covered at the congress, including veterinary education; zootechnics, which also deals with all branches of animal husbandry and animal behaviour, will comprise one of the sections.

Abstracts of papers and short communications will be published before the opening of the congress. These should be submitted, in accordance with the rules of the World Veterinary Association (WVA), by national and associated members only. The Organizing Committee cannot accept scientific material for publication in congress proceedings directly from veterinary specialists. Information on the preparation of abstracts of papers and communications, as well as general information, may be obtained from the Organizing Committee Secretariat, Room 404, 1/11 Block B, Orlikov Pereulok, Moscow 107139, USSR.

According to the WVA Constitution, the working languages of the congress will be Russian, English, French, German and Spanish.

A post-congress tour including visits to veterinary research institutions and educational establishments, as well as collective and state farms in different parts of the USSR, will be organized for interested participants.

International courses in pig and poultry husbandry

The ninth series of international courses in pig and poultry husbandry will be held at Barneveld College, the Netherlands, from 29 August 1979 to 1 March 1980. They are primarily intended for students from developing countries who perform teaching, advisory or managerial functions in pig and/or poultry husbandry or related fields. The courses will be conducted in English and will take students to a post-diploma level. The coverage includes theoretical studies, practicals and demonstrations, excursions, farm work, laboratory techniques and writing reports.

Details regarding admission requirements, fees, accommodation and the two syllabuses can be obtained from: The Director, Barneveld College, P.O. Box 64, 3770 AB Barneveld, the Netherlands.

Second International Symposium on Veterinary Epidemiology and Economics

Veterinary epidemiology has expanded very rapidly in recent years, and many new techniques have been developed and applied to a diverse range of problems. Economic methods have also been applied to disease control and the economic context is now an important factor in what used to be purely technical decisions.

The Second International Symposium on Veterinary Epidemiology and Economics will be held at the Australian Academy of Science, Canberra, from 7 to 11 May 1979. Major components of the Symposium will include: information gathering and processing; evaluation of alternative policies for disease control; operation of disease control programmes; problem areas, including communication between veterinarians and animal owners, definition of the disease status of countries, and other current issues; and education in veterinary epidemiology and economics.

Further information about the Symposium can be obtained from: The Secretary, Second International Symposium on Veterinary Epidemiology and Economics, Epidemiology Branch, Australian Bureau of Animal Health, Department of Primary Industry, Canberra, ACT 2600, Australia. ■

Bases para el mejoramiento de la producción de lana

By R.W. Ponzoni Rey. Livraria e Editora Agropecuária Ltda, Porto Alegre, RS, Brazil. 1977. 90 pages, numerous tables and references. In Spanish. Price: 45 cruzeiros.

Following his books on modern aspects of sheep production, published in Uruguay in 1971 and 1973, Ponzoni Rey devotes the present publication exclusively to wool; there is no doubt that it will fill a gap in the available literature on sheep production in the temperate zone of Latin America.

The author states in his introduction that this publication is intended mainly for students and professionals in Argentina and Uruguay. A general introducton is followed by a discussion of the importance of wool characteristics, with reference to the different traits that influence the quality of wool and its price. The progress that can be expected when selecting for greasy fleece weight and other characteristics (especially fineness) is analysed. Two appendixes supplement the text. The first deals with the theoretical background to selection and demonstrates the use of a fixed model (this will not be readily understood by most non-specialist readers). The second offers a practical plan for selection within a herd, describing which animals should be selected and when and how performance should be evaluated. The precise instructions on the sampling and evaluation of data will be of great value to those concerned with improving wool production in the region, because systematic production recording and selection are not currently practised in the majority of flocks.

B.M.-H.

"Alimentation des ruminants" (Ruminant feeding)

Edited by the Institut national de la recherche agronomique (INRA), route de Saint-Cyr, 78000 Versailles, France. 1978. 600 pages, linen bound. Price: F140 (not including postage). (In French)

The objective of this book is to provide all those dealing with animal feeding precise information concerning feed requirements, intake capacity of animals and the nutritive values of feeds. It proposes a completely new basis for ruminant feeding. Its aim is:

To integrate all the present knowledge;

To put such information into a format that can be used more or less directly in practice; and

To retain, as far as possible, methods of reasoning and forms of presentation that have proved successful, particularly as regards ration formulation.

The book is divided into three parts: the nine chapters of part one summarize current knowledge on digestion, metabolism and intake in ruminants and on the requirements for maintenance and for various types of production. In the second part (six chapters) the nutrient requirements and recommended dietary allowances are presented for the various categories of ruminants found in France: meat and breeding calves; growing and fattening cattle; milking cows; beef cows; ewes, ewe and ram lambs; goats, doe and buck kids. In each case, the origins and degree of accuracy of the levels recommended are presented first, followed by some examples of their application in formulating rations. The third part is devoted to tables of chemical compositions, digestibility and nutritive value of the main feeds utilized in France (there are about 300 main feeds). Since these tables are entirely new, an introductory chapter describes the origin, method of calculation and degree of reliability of the values given. Tables are appended, which summarize available data on fermentation characteristics of silages, content of trace elements, and on the nutritive value of some forages and by-products used in the tropics and in the Mediterranean zones.

Two new energy units have been adopted in the tables of the nutritive values of feeds and recommended standards — the feed unit for lactation (French acronym: UFL) and the feed unit for meat production (UFV). Two systems of calculating the protein values of feeds and the protein requirements of the animals have also been used — the classical digestible crude protein system, and the new PDI system (estimating the true protein that is actually digestible in the intestine). A "fill unit" (UE) allows the prediction of the approximate voluntary dry matter intake for all circumstances.

This book has been written by a group of INRA scientists and agricultural university teachers who had previously presented the framework of it at the "VIIIe Journées d'information" (also known as the "Grenier de Theix"), organized by the Centre de recherches zootechniques et vétérinaires, INRA de Theix, in December 1975.

M.C.

Animal feeds from waste materials

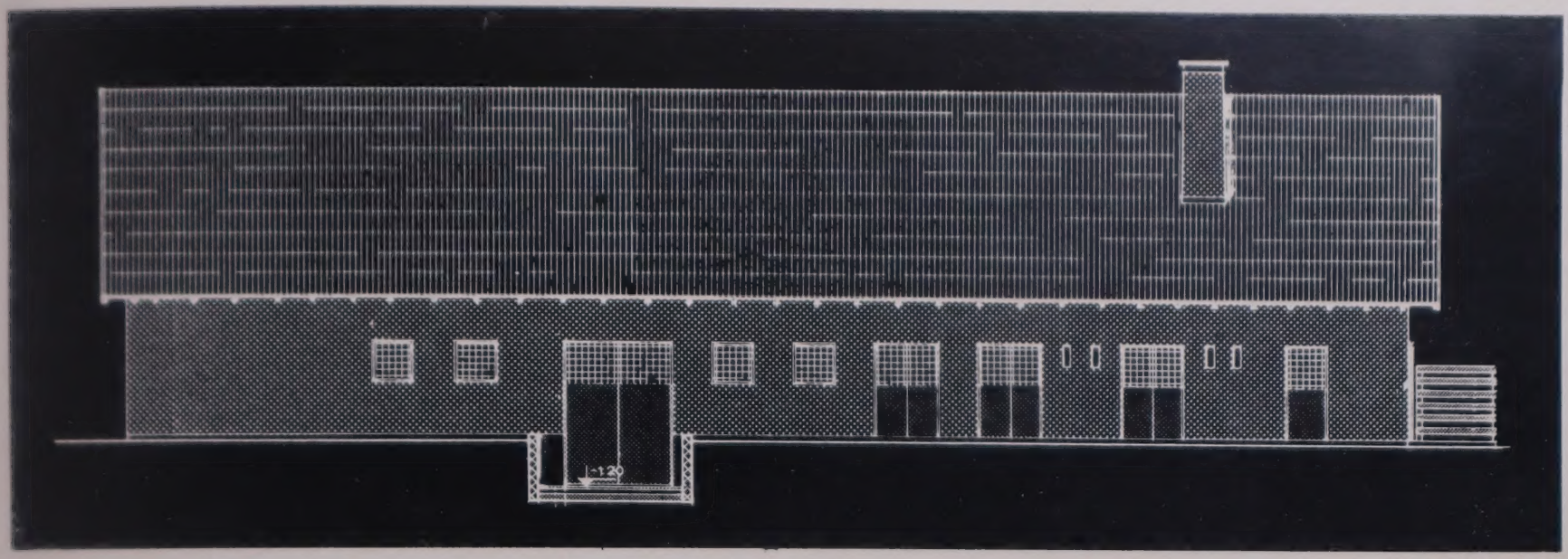
By M.T. Gillies. Noyes Data Corporation, Park Ridge, N.J. 07656, USA. 1978. 355 pages. Cloth bound. $US39.00

This book describes 108 US patents designed for processing industrial and agricultural wastes with a view to their further utilization as animal feeds.

Individual chapters cover: processes for the utilization of molasses (Chapter 1); processes for the production of feeds from high cellulose wastes (Chapter 2); processes for agro-industrial by-products (Chapter 3); processes for the production of animal feeds from cattle/poultry manure, sewage and other animal waste products (Chapters 4 and 5); and whey (Chapter 6), which is a difficult substance to dispose of.

In summary, this book essentially concentrates on the technological aspects of the processes. It is therefore mainly for the use of feed-compounding industries.

M.C.



slaughterhouse and slaughterslab design and construction

by P.J. Eriksen, FAO.
FAO Animal Production and Health Paper No. 9
33 pages, with 58 figures.
Available in English
(French and Spanish in preparation)
from Distribution and Sales Section
Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla, 00100 Rome, Italy
or through any of the sales agents and booksellers
listed on the back cover
Price: $3.00.*

This publication provides information on the operation, design and construction of rural slaughterhouses and slaughterslabs in developing countries. The throughput envisaged in the designs allows for 30, 60 or 100 head of cattle and 150 small animals to be slaughtered in a 5-hour working day. The publication contains three main chapters concerning: planning; design and construction; and equipment. All details concerning planning and implementation of a slaughterhouse or a slaughterslab project are provided in such a way that any competent builder should be able to follow them without further instruction. Allowance has been made for maximum use of local materials so that costs can be kept to a minimum.

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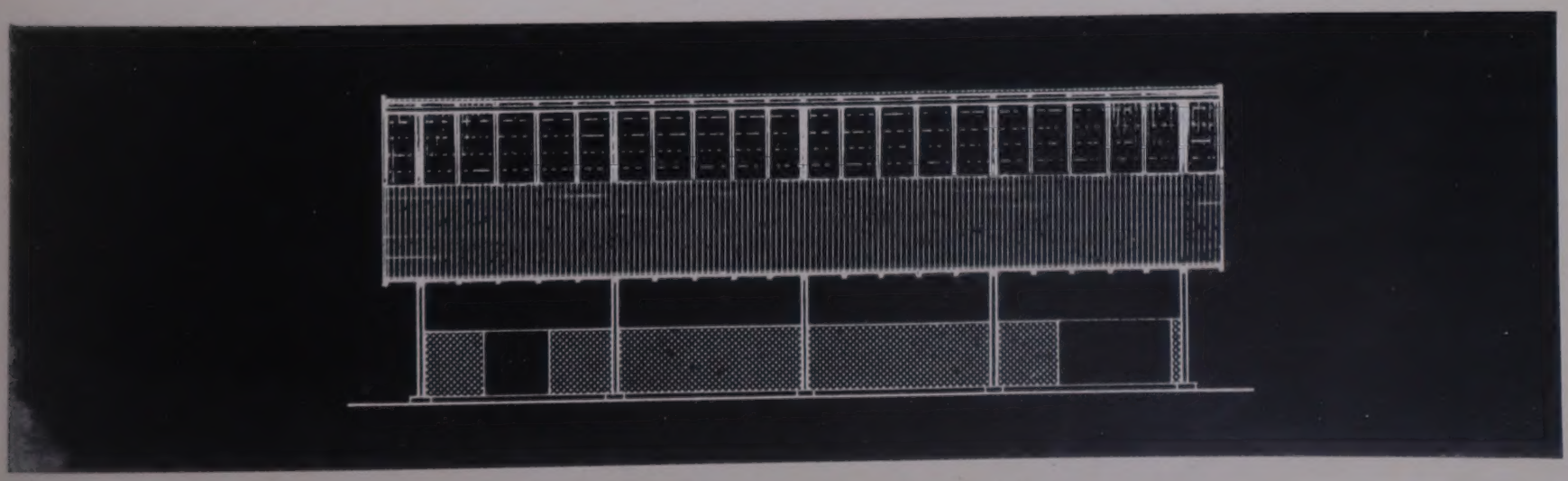

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Société nationale d'édition et de diffusion, 3, boulevard Zirout-Youcef, Algiers.
St. Augustinus Boekhandel, Abraham de Veerstraat 12, Willemstad, Curaçao.
Editorial Hemisferio Sur S.R.L., Librería Agropecuaria, Pasteur 743, Buenos Aires.
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